FactoryLink ECS

Core Tasks Configuration Guide

Persistence
Timer
Counter
File Manager
Print Spooler
Math and Logic
Scaling and Deadbanding

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Persistence

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Persistence

Persistence

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Persistence

Use the Persistence task to save the values of an activeFactoryLink application at predetermined times so if FactoryLink is shut down unexpectedly, useful data is not lost. Then, when you restart FactoryLink with the warm start command-line option, the Run-Time Manager restores the last save of the real-time database from the persistence save file.

PERSISTENCE OVERVIEW

The memory-based real-time database represents the current state (values) of elements. The real-time database is a collection of domain instances. Elements in the database may have default values which are placed into the domain instance when it is initialized.

The values of the elements in a domain instance are lost when the domain instance is closed. When the domain instance is opened again, its elements are initialized to their default values.

This can be a problem if FactoryLink unexpectedly shuts down because of an event such as a power loss or a faulty process. Useful information can be lost because of the initialization of the real-time database to its default values when the system is restarted. Since most of the information in FactoryLink applications is the accumulation of data over time, you cannot recover this data unless it is saved. Persistence provides a way of saving the state of an active FactoryLink application.

Persistence is the ability of an element to maintain its value over an indefinite period of time. Non-persistent elements lose their value when the Run-Time Manager exits and shuts down the real-time database. However, the values of persistent elements are written to disk so they are not affected when the real-time database shuts down.

The job of the Persistence task, therefore, is to save persistent data. The task offers the following features.

- Runs on all FactoryLink platforms.
- Lets you configure on a per-tag basis or on entire domains which elements are persistent and when their values are saved to disk.

- Saves one or all domain instances to disk while a FactoryLink application is running.
- Allows you to specify either a warm or cold start when initializing a domain instance.

  Cold start initializes all elements to their default values as configured in the Configuration Manager Main Menu. Persistent elements are not restored to their previous values but are initialized to their default values.

  Warm start initializes all non-persistent elements to their default values just like a cold start and restores all persistent elements in the domain instance to their previously saved values.
- Uses its own internal disk cache to increase speed and reduce disk I/O overhead.
- Resolves configuration changes to the application.
- Allows you to specify a trigger element that triggers the Persistence task to copy the current save file to a backup file.

Principles of Operation

Persistence begins during application development. Whether configuring a new application or reconfiguring an existing application, you must first determine which elements are persistent, when the values of the persistent elements are saved to disk, and how these saved values are restored during a warm start. Then, specify this information on the Tag Definition dialog when defining a persistent element.

At run time, the Persistence task saves the values of the persistent elements to its own internal disk cache and the task writes the data to disk from there. Saving the persistent values to memory first increases processing speed and ensures all values meant to be saved are saved within the allotted time.

The Persistence task runs under each domain that requires persistent data to be saved. The RESOLVE program (executed by the FLRUN command) creates a blank persistence save file for each domain the first time it is executed. During its initialization, the Persistence task loads the persistence save file to determine which elements in the application are persistent and when the values of those elements are to be saved. It also loads the PERSIST.CT file to get specific information about the configuration of the Persistence task itself.

When you perform a warm start, the current domain's Run-Time Manager restores the domain instance's real-time database from the persistence save file. It restores the values of the persistent elements to the last values saved by Persistence.

To perform a warm start of FactoryLink, use the warm start argument **-w**. In Windows and OS/2, add the -w to the command line for the icon used to start FactoryLink; in UNIX, either pass the -w to the FLRUN command, or add it to the line in the script file used to start FactoryLink.

See the table below for details:

Table 1-1

Starting FactoryLink using the -w (warm start)	
Windows	Create a new Start FactoryLink icon, following the steps below: 1. Click once on the Start FactoryLink icon to select it. 2. Click Edit>Copy. 3. Click Edit>Paste. A copy of the Start FactoryLink icon is pasted into the FactoryLink Program Group. It is labelled Copy of Start FactoryLink. 4. Change its properties by: a.) clicking File>Properties b.) clicking in the command line, c.) pressing the End key (to get to the end of the command line) d.) adding -w to the end of the command line, preceded by a space. 5. Click File>Rename and change the icon's label to Warm Start FactoryLink. Press the Enter key.
OS/2	Create a new Run Time Manager icon, following the steps below: 1. Right click once on the Run Time Manager icon to select it. 2. Click Copy. a. Enter Warm Start for the icon's new name. b. Click Copy. 3. Right click once on the Warm Start icon to select it. 4. Click Settings. In Optional Parameters, type **-w**. 5. Close window.
UNIX	Edit the command line as $ flrun -w -d -nshared <ret> or add the -w to the script file using above syntax.

Before starting the Run-Time Manager, the FLRUN command executes the RESOLVE program to check the persistence save file for any configuration changes you made. The need to check for configuration changes is discussed in "Resolving Configuration Changes" on page 17.

Resolving Configuration Changes

After you shut down a FactoryLink application, you might reconfigure part of the application using the Main Menu or the Application Editor. This means the elements and their values stored in the persistence save file either may not exist or might not have the same data type when you restart the application. Before each FactoryLink session is restarted, the element names stored in the persistence save file must be checked for changes against the OBJECT.CT and the DOMAIN.CT files.

This resolving of configuration changes is done by the RESOLVE.EXE (resolve on UNIX systems) program. The FLRUN command automatically executes this program before it starts the Run-Time Manager for a particular FactoryLink session.

The RESOLVE program serves three purposes.

- Creates the blank persistence save file the first time it is run.
- Manages the changes between the persistence save file and the FactoryLink configuration files.
- Determines if the persistence save file is usable and, if not, the program looks for and uses the persistence backup file.

RESOLVE makes the following changes.

- Removes element names from the persistence save file that have been deleted from the application or changed to a different data type.
- Updates the element name ID for element names that were deleted, then recreated.
- Adds element names to the persistence save file that have been reconfigured to have persistence. These element names are added with no data values.
- Copies the persistence backup file over the persistence save file if the save file is corrupted.

Configuring Persistence for Existing Applications

The methods for configuring persistence are the same for both new and existing applications. For existing applications, however, you must first run the FactoryLink Conversion Utility (FLCONV). FLCONV assigns the following default persistence options to an existing application:

- Saving—No persistence
- Restoring—Set Change Status OFF

After you run the FLCONV utility, you can change the persistence options for the elements in that application. Determine the database elements in the application to be persistent and configure persistence for the elements, either individually or for the entire domain. These methods are explained in "Configuring Persistence for New Applications" on page 18.

Configuring Persistence for New Applications

To use the warm start feature, you must configure which elements are persistent, when their values will be saved, and how to restore their change-status bits during a warm start of FactoryLink.

You can configure persistence in one of two ways.

- For individual elements.
- For all of the elements in a domain.

The following sections discuss how to configure persistence for both cases.

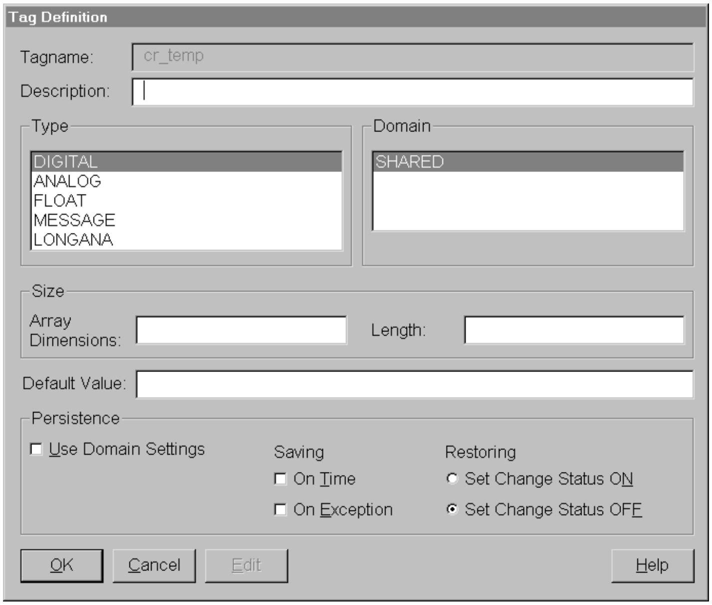
CONFIGURING PERSISTENCE FOR INDIVIDUAL ELEMENTS

Configure persistence for individual elements in the Tag Definition dialog. The Tag Definition dialog is displayed when you

- Define a new element in either a configuration panel from the Main Menu or in an animation panel in the Application Editor.
- Press Ctrl-T in a Tag field for a previously defined element.

Perform the following steps to configure persistence for individual elements.

1 Define a new element or press Ctrl- to display the Tag Definition dialog.



2 Choose the required options from the Persistence section of the Tag Definition dialog.

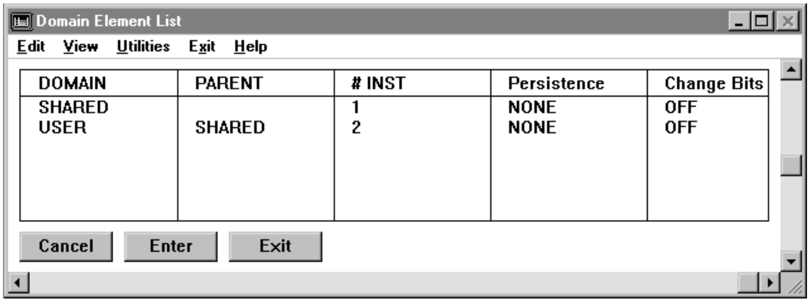
Use Domain Settings	Saves the value of the persistent element according to the options chosen for the domain's persistence. The Saving and Restoring options are disabled when this option is chosen. Deselect Use Domain Settings to enable the Saving and Restoring options for this element specifically.

Saving	Indicates when the value of the persistent element is saved. This can be one of the following. On Time—Saves the value of the persistent element on a timed trigger. On Exception—Saves the value of the persistent element whenever its value changes. On Time and On Exception—Saves the value of the persistent element on a timed trigger and when its value changes.
Restoring	Indicates how to restore the persistent element. This can be one of the following: Set Change Status ON—Restores the persistent element with its change-status bits set to 1 (ON) after a warm start. Set Change Status OFF—Restores the persistent element with its change-status bits set to 0 (OFF) after a warm start. This is the default. No Options Selected—The element is not marked as persistent.

CONFIGURING PERSISTENCE FOR ALL ELEMENTS IN A DOMAIN

Complete the following steps to configure persistence for all elements in a domain in the Domain Element List.

1 Choose View>Domain List to display the Domain Element List.



The list includes the domain name, the parent domain, the number of application instances available for the domain, domain persistence, and the setting for change bits. Use the Persistence and Change Bits fields to configure persistence for an entire domain.

2 Choose the Persistence field for the row containing the domain to be made persistent. Enter the method you want to use to save the elements' values. This can be one of the following.

None	The elements in the domain are not marked as persistent.
Timed	Saves the values of the domain's elements on a timed trigger.
Except	Saves the values of the domain's elements whenever their values change.
Both	Saves the values of the domain's elements both on a timed trigger and whenever their values change.

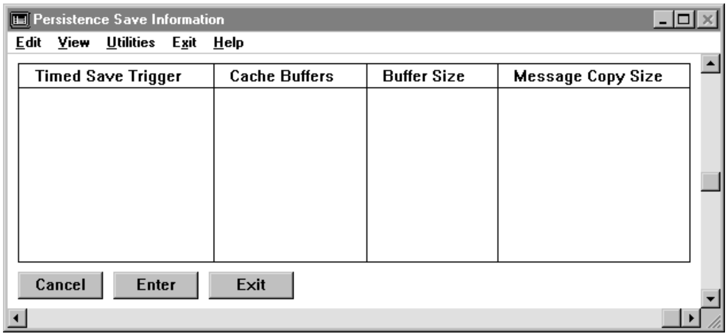
3 Choose the Change Bits field for the same domain and enter how you want to restore the elements' change-status bits. This can be one of the following.

ON	Restores the domain's elements with their change-status bits set to 1 (ON) after a warm start.
OFF	Restores the domain's elements with their change-status bits set to 0 (OFF) after a warm start.

For example, you may have several Math & Logic procedures triggered by digital tags, but the application controls when these tags are force-written to a 1 (value=1; change-status bits=1). If you perform a warm start with Change Bits ON, then all of the digital tags' change-status bits are written to a 1 and all of your IML procs run at once.

Configuring the Persistence Task

In addition to configuring persistence for elements and domains, you must also configure the operation of the Persistence task itself. Choose Persistence to display the Persistence Save Information panel.



Following are field descriptions for this panel.

Timed Save Trigger Name of an element used to trigger a timed save of the values of all elements marked as persistent by time.

When the element defined here is triggered at run time, the Persistence task reads all elements in the current domain instance configured to be saved on a timed basis and writes their values to disk (the persistence save file).

Leave this field blank if no timed saves are required for the application.

A Tag Definition dialog is displayed when you click on Enter if the tag specified in this field is not already defined.

Valid Entry: standard element tag name
Valid Data Type: digital, analog, longana, float, message

Cache Buffers

Number between 0 and 32766 indicating the number of buffers to be set aside for the Persistence task's internal disk cache. The default is 16. The greater the number of buffers, the less the task writes to the disk, which improves performance.

Use the following guidelines to aid in determining the number of buffers:

- How often the data is changing

- How much of the data is changing

- The size of the data that is changing

While there is no definitive way to determine the ideal number of buffers, you can use the total number of tags of each data type that are persistent in the application to calculate an estimation of the maximum buffer size. The formula is given as follows:

max buffer size = [(# of analog + digital)*2] + [(# of longana)*4] +
[(# of float)*8] + [(# of msg)*len]

where **len** is the message length from the Persistence panel. Then select a combination of number of buffers multiplied by buffer size that equals this value. (See Buffer Size, below.)

If you enter 0, no disk caching is done. This can be desirable if the operating system itself uses an efficient disk caching system (such as UNIX).

Valid Entry: numeric value of up to 32766 (default = 16)

Buffer Size

Number between 64 and 32766 indicating the size, in bytes, of each buffer in the cache. The default is 512. The larger the buffer, the less the task writes to the disk, which improves performance.

Valid Entry: numeric value of up to 32766 (default = 512)

Message Copy Size

Number between 80 and 32766 indicating the maximum length allowed for message elements during persistent saves. FactoryLink uses the number entered here when it reads elements from the real-time database, and when restoring values during a warm start. The default is 2048.

Valid Entry: numeric value of up to 32766 (default = 2048)

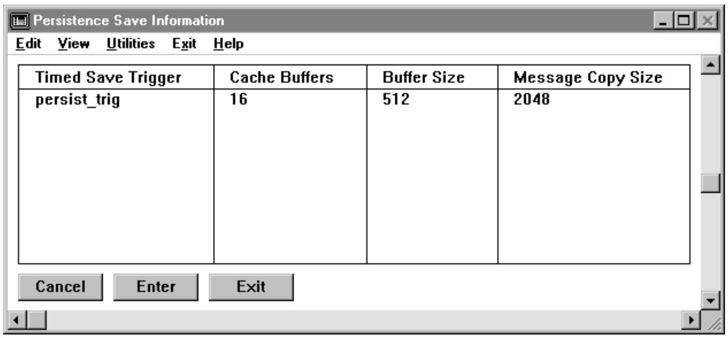
Backup Trigger Name of an element used to trigger a backup of the current persistent save file.

A Tag Definition dialog is displayed when you click on Enter if the tag specified in this field is not already defined.

At run time, when the application triggers the element defined here, the Persistence task copies the current persistence save file to a backup file.

Valid Entry: standard element tag name
Valid Data Type: digital, analog, longana, float, message

The completed panel resembles the following sample:



In this example, when the value of the element persist_trig changes to 1 (ON), it triggers the Persistence task to write to disk the values of all elements in the application configured as persistent by time. The number of buffers set aside for the internal cache is 16 with 512 bytes per buffer. A disk cache is a way to compensate for the slowness of the disk drive in comparison to RAM (memory). The Persistence task's cache process speeds up computer operations by keeping data in memory. Rather than writing each piece of data to be saved to the hard disk, the task writes the data to its internal disk cache (reserved memory area). Then, when the disk is not busy with other processing or when the cache process can perform several writes in an order that minimizes the movements of the disk's heads, the *cache process* writes the saved data to the hard disk.

The maximum length for message elements during persistent saves is 2048 bytes. When the value of the element persist_backup changes to 1, it triggers Persistence to copy the current persistence save file to a backup file.

Persistence Task Start Order

This section describes some possible effects of warm restarts on the application depending on when Persistence starts and what has happened to the other tasks during the startup process. This discussion ONLY applies if the TASKSTART_? tags (from the System Configuration Table) are made persistent.

Example 1: Persistence starts last and shuts down first

After the application starts, the values of the TASKSTART_? tags are 1, so Persistence saves a 1 as their last known value. At shutdown, because Persistence stops first, Persistence does not “see” the change in value of the TASKSTART_? tags from 1 to 0 (zero), so the saved values remain as 1. On a warm start of the application, the TASKSTART_? tags for all tasks that were running at shutdown will be restored to 1 and therefore, their tasks will start. It is important to note that these same tasks will be started regardless of their “R” flag settings in the SYS.CT file. (This assumes no manual starts/terminations.)

Example 2: Persistence starts first and shuts down last

Because Persistence starts first, it “sees” the application starting and therefore sees the values of the TASKSTART_? tags at 0. If there is a termination during the startup process, then, because Persistence stops last, it saves a 0 as the last known value of the TASKSTART_? tags. On a warm start of the application, none of the tasks will be started because all of the tasks’ TASKSTART_? tags had a last known value of 0.

The shutdown order is more significant than the startup order if the tags are saved on change. In general, specify the Persistence task to shutdown first (and therefore, start last) so that the saved values in the Persistence save file reflect the last known running state of the application at shutdown. Then, the warm start will restore it to that state, which is the purpose of the Persistence task.

Persistence and Digital Elements

The way a digital element is used in an application affects how that element is configured for persistence. Digital elements are often used to trigger some action in an application. Examples include starting a Math and Logic procedure or starting a FactoryLink task. When a digital element is triggered (its value is changed from 0 to 1 or force-written to 1), FactoryLink starts the associated procedure or task. When FactoryLink is warm-started, these elements are restored to their last saved value. Configuring a digital element as persistent with its value to be restored with Force Change Status ON can be used to start any procedure or task associated with this element after the system is initialized.

However, the digital elements RTMCMD and RTMCMD_U, cannot be made persistent. This is because when the value of these elements is set to 1, the FactoryLink system shuts down. Therefore, making these elements persistent immediately shuts down the system as soon as it comes up.

Note that the R (Run) flag for each task in the System Configuration Information panel supersedes the value of the digital start trigger associated with a task.

Examples

The following examples show the relationship between the R flag in the System Configuration Information panel and the restored value of a digital element:

Example 1:

The R flag is NOT set for task A and the digital start trigger associated with task A is defined as persistent by Exception (always updated) with Force Change Status ON if:

- Task A is running when the system is shut down, then the value of the task's digital start trigger is 1. When a warm start is performed, the system restarts task A because the value of the digital start trigger is restored to 1.
- Task A is not running when the system is shut down, then the value of the task's digital start trigger is 0. When a warm start is performed, the system does not restart task A because the value of the digital start trigger is restored to 0.

Example 2:

The R flag IS set for task A and the digital start trigger associated with task A is defined to be persistent by Exception (always updated) with Force Change Status ON if:

- Task A is running when the system is shut down, then the value of the task’s digital start trigger is 1. When a warm start is performed, the system restarts task A because the value of the digital start trigger is restored to 1.
- Task A is not running when the system is shut down, then the value of the task's digital start trigger is 0. When a warm start is performed, the system still restarts task A because, even though the value of the digital start trigger is restored to 0, the task’s Run flag is set and the Run flag supersedes the restored value of the digital start trigger.

PERSISTENCE SAVE FILE NAME

The persistent data is saved in a unique persistence save file for each domain instance. The persistence save files have the extension.PRS and are located in the /FLAPP/FLNAME/FLDOMAIN directory.

where

FLAPP	is the translated application environment variable.
FLNAME	is the translated application environment variable.
FLDOMAIN	is the translated domain environment variable.

The name of each persistence save file is {FLUSER}.PRS where **FLUSER** is the translated environment variable for the domain user name. The persistence save file contains the saved values for that domain user.

For example, in Windows, where the FLRUN.BAT file sets the Shared FLUSER environment variable to SHAREUSR, but the User domain FLUSER environment variable remains at the default setup in the AUTOEXEC.BAT file, the Shared persist file is named SHAREUSR.PRS and the User persist file is named FLUSER1.PRS.

The persistence backup files are in the same place and have the same name, except they have the extension.BAK (.bak in UNIX).

Editing Tag Persistence Settings Using BH_SQL Utility

It may be useful for users to be able to make mass edits to the current persistence settings for defined tags in the OBJECT configuration table, such as changing the field entries for all tags that currently are blank, to a specific setting such as NONE. This can be done using the BH_SQL utility provided with all FactoryLink systems. This utility

1. Modifies the OBJECT.CDB file in the FLAPP directory.

2. Modifies the TAGPERWHEN field in that file.

TAGPERWHEN (meaning “Tag is saved when?”) is the text equivalent of the radio buttons seen on the Tag Definition dialog when defining a tag or using CTRL-T to view the tag definition. The possible values are:

- NONE - tag is not persistent
- left blank - same as NONE
- DOMAIN - save based on domain persistence definition as configured in the Domain configuration panel.
- TIMED- save on timed trigger
- EXCEPT - save on change

The procedure updates the table changing all instances of a specific entry in the TAGPERWHEN field at one time to a new value.

Prior to executing the instructions below, we recommend you make a backup of the application using the FLSAVE utility or some other backup utility. At least make a backup copy of the OBJECT.CDB and OBJECT.MDX files so if anything goes wrong during the procedure, the backup can be restored with no damage done to the application. The general syntax can be modified to update the persistence setting for any group of tags from the current settings to any valid new setting as a group, by varying the literal values in the first and second instance of tagperwhen = '????'.

Follow the steps below to use the BH_SQL utility:

1. Run BH_SQL by typing the program name at a prompt for all systems except MS Windows. For MS Windows, run the program from the Program Manager - File>Run menu selection.

2. Type at the BH_SQL prompt:

   ```
   SQL >  connect  flapp <ret>
   ```

   where flapp is the actual path to the flapp directory as defined in the FLAPP environment variable.

3. Type at the BH_SQL prompt (quote marks are all single quotes not double quotes):

   ```
   SQL >  update object set tagperwhen = 'NONE' where tagperwhen =
   ''  <ret>
   ```

where the first instance of tagperwhen = 'NONE' is the desired new value for the field and the second instance is the current value of the field (in this case a blank entry). This command finds all records in the OBJECT table for which the current tag persistence setting is blank and changes all the settings to NONE.

Use the following command if you have a large number of tags configured to be saved as defined for the domain configuration and you want to change the setting for all of these tags to be saved individually when they change value or on exception.

```
SQL >  update object set tagperwhen = 'DOMAIN' where tagperwhen =
'EXCEPT'  <ret>
```

Type QUIT at the BH_SQL prompt once all desired changes have been made.

- **PERSISTENCE**
- *Editing Tag Persistence Settings Using BH_SQL Utility*
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Part II

Event and Interval Timer

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Event and Interval Timer

Event and Interval Timer

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Event and Interval Timer

Use the Event and Interval Timer task to define timed events and time intervals that initiate and control any system function in run-time mode.

- Timed events occur at a specific time not more than once every 24 hours (for example, Monday at 8:00 am). They are configured in the Event Timer Table.
- Time intervals occur at least once every twenty-four hours at regular intervals of the system clock (for example, every 60 seconds). They are configured in the Interval Timer Table.

The Event and Interval Timer task links timed events and intervals to real-time database elements used as triggers whenever the event or interval occurs. It is defined in the SHARED domain.

The use of Event and Interval timers requires an understanding of change-status flags. Refer to the *FactoryLink Fundamentals* manual for this discussion.

There is no limit, except the amount of available memory, to the number of event and interval timers that can be defined.

PRINCIPLES OF OPERATION

The Event and Interval Timer task operates in synchronization with the system clock. For each defined interval or event, you must create a digital element in the real-time database. When the system clock matches the specified event or interval, the task forces the value of this digital element to 1 (ON).

The Event and Interval Timer task also updates global information used by FactoryLink such as the current time, the day of the week, and the month. Such global information is stored in predefined FactoryLink real-time database elements, known as reserved elements, each of which is one of the following data types: analog, long analog, or message.

The following table lists reserved elements that are updated by the Event and Interval Timer task.

While the Timer task is running, these reserved elements are constantly updated. In order for the Timer task to run, you must have entered an R flag for the Timer task in the System Configuration Table in the Configuration Manager Main Menu.

Table 2-1

Reserved Element	Data Type
A_SEC	Analog
A_MIN	Analog
A_HOUR	Analog
A_DAY (Day of month)	Analog
A_MONTH	Analog
A_YEAR	Analog
A_DOW (Day of week)	Analog
A_DOY (Day of year)	Analog
DATE (DOW MM-DD-YYYY)	Message
TIME (HH:MM:SS)	Message
DATETIME (DOW MM-DD-YYYY HH:MM:SS)	Message

Table 2-1 (Continued)

Reserved Element	Data Type
YYMMDD (YY-MM-DD)	Message
SECDAY (Seconds since start of current day)	Long Analog
SECYEAR (Seconds since start of current year)	Long Analog
SECTIME (Seconds since January 1, 1980)	Long Analog

Changing the Operating System Date and Time

To change the operating system date and time while FactoryLink is running, shut down the Timer task, change the date and time, and restart the task. Otherwise, the Timer task tries to catch up by processing missed intervals.

Configuring the Event and Interval Timer Task

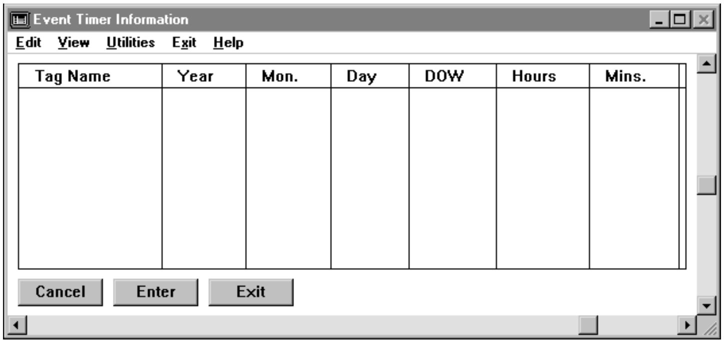
Use this task to signal the occurrence of specified events or intervals by writing to digital elements in the FactoryLink real-time database.

The Event and Interval Timer task uses the SHARED domain. Before opening and configuring the Event and Interval Timer task, ensure the current domain selected is SHARED in the Configuration Manager Domain Selection box.

Event Timer Information Dialog

Use Event Timer to define events that only occur not more than once every 24 hours. For example, use event timers to start or stop reports, and as triggers to read and write recipe files.

Choose Event Timer to display the Event Timer Information dialog.



Following are field descriptions for this dialog.

Tag Name — Element name (for example, time8am) to be assigned to the event. When the event occurs, the element is forced to 1 so its change-status bit is set to 1. The Timer task resets all event timers back to zero at midnight. You can assign more than one element to the same event.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of digital in the Type field. Accept this default.

Valid Entry:	standard element tag name
Valid Data Type:	digital (default = digital)

Year, Mon. Day DOW — Specify a period when an event is to occur. Enter a Year (Year) month (Mon) day (Day) and day-of-the-week (DOW) or combination as explained below.

When using Day and Month, the event occurs only on this date in the specified month in the specified year. If you do not enter a month, the event occurs on this date every month. If you do not enter a month and year, the event occurs on this date every month of every year.

When using DOW, if you enter a month, the event occurs on this day every week of that month only. If you do not enter a month, the event occurs on this day every week. If you enter a month and year, the event occurs on this day every week of the specified month during the specified year. If you do not enter a month and year, the event occurs on this day every week of every year.

Year	4-digit year such as 1994.
Month	1-12 or MMM (Example: March is 3 or MAR for first three letters of the month's name.)
Day	1-31 indicating the day of the month the event is to occur. If the event is to occur once every day, leave this field blank.
DOW	MON - SUN First three letters of a weekday. If the event is to occur once every day, leave the field blank.
Hours	Refer to the following discussion of Hours, Mins., and Secs.

Mins. Refer to the discussion of Hours, Mins., and Secs. that follows.

Hours, Mins. Secs. Hours, Mins. (minutes), and Secs. (seconds) fields define the specific time (in 24-hour format) at which an event is to occur. The event timer assumes a default value of 0 for blank fields. The conventions for use are:

Hours Hour the event is to occur (0 to 23).

Mins. Number of minutes (0 to 59) after the hour the event is to occur. If the event is to occur on the hour, leave this field blank.

Secs. Number of seconds (0 to 59) after the minute (or hour) the event is to occur.

Between midnight (00:00:00) and the time indicated in the Hours, Mins., and Secs. fields, the value of the element to which an event is linked is 0 (OFF). After the timed event occurs, the element's value changes to 1 (ON) and stays this way until midnight, when it changes back to 0 (OFF).

Hours 0 - 23 (0 is midnight and 23 is 11:00 pm.)

Mins. 0 - 59

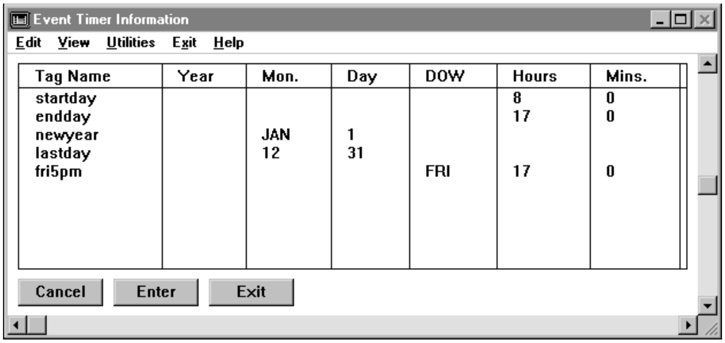
Secs. 0 - 59

First Value that determines the action taken upon system startup, if startup occurs after a timed event. Because this field only affects events scheduled for the current date, the system checks the date before changing any values.

Yes The element's value immediately changes to 1 (ON), indicating the timed event has occurred for that date. The change-status flags are also set to 1 (ON).

No Default—the element's value is left “as is” and does not change to 1 (ON) until the next occurrence of the timed event.

When all information has been specified, the dialog resembles the sample dialog below:



In this example, the startday element has a value of 0 between midnight and 8:00 am and 1 between 8:00 am and 11:59 pm and 59 seconds (23.59.59) each day of the year.

Similarly, the endday element has a value of 0 between midnight and 5:00 pm and 1 between 5:00 pm and 11:59 pm and 59 seconds.

The newyear element's value has a value of 1 on January 1 of each year and 0 on all other days.

Similarly, the lastday element's value has a value of 1 on December 31 of each year and 0 on all other days.

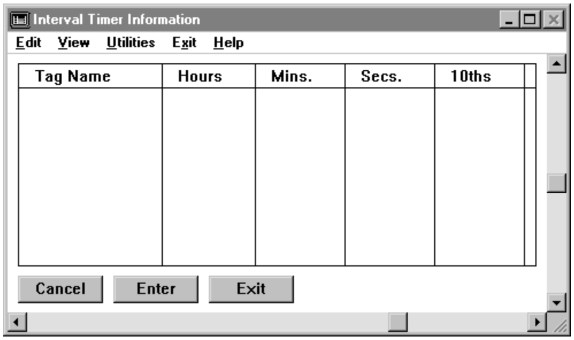
The fri5pm element has a value of 1 each Friday between 5:00 pm and midnight.

Click Enter to save the information and return to the Main Menu when you finish setting the event timers.

Interval Timer Information Dialog

Use Interval Timer to define events that occur at least once every 24 hours at regular intervals of the system clock, such as every second or every two hours. For example, use interval timers as triggers in Polled Read or Write PLC tables and in Send or Receive tables for FL/LAN Network configurations.

Choose Interval Timer to display the Interval Timer Information dialog.



Following are field descriptions for this dialog.

Tag Name — Name of the element (for example, sec5) to be assigned to the interval. You can assign the same interval to more than one element.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of digital in the Type field. Accept this default.

Valid Entry: standard element tag name

Valid Data Type: digital (default = digital)

Hours Mins. Secs. 10ths — Hours, Mins. (minutes), Secs. (seconds), and 10ths (tenths of a second) fields define the interval at which an event is to occur. If these fields are left blank, the interval timer assumes a default value of 0. At least one of these fields must be filled in with a valid entry (not zero, as it is not considered a valid entry) or else the system does not allow the ITimer to start, but instead displays the error message:

"Bad data in ITimer record (record#), file (itimer.exe)."

Depending on the interval you specify, the timer starts at midnight or at system startup. If the interval can be divided evenly into 24 hours (86,400 seconds, or 1,440 minutes), the timer runs as if it started at midnight. If the interval cannot be evenly divided into 24 hours, the timer starts at system startup.

Conventions for use:

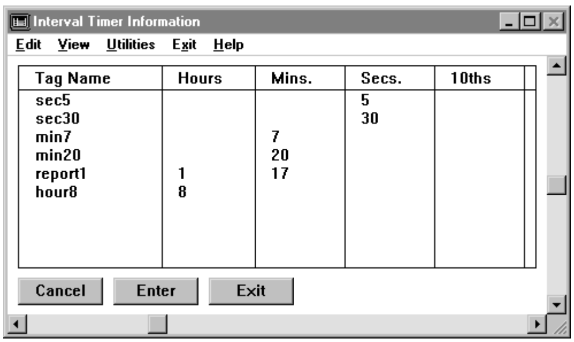
Hours — A number between 0 and 23 that indicates the length, in hours, of the interval. Example: Every 2 hours (2), every 3 hours (3), etc.

Mins A number between 0 and 59 that indicates the length, in minutes, of the interval. Example: Every 5 minutes (5), every 10 minutes (10), etc.

Secs A number between 0 and 59 that indicates the length, in seconds, of the interval. Example: Every second (1), every 7 seconds (7), etc.

10ths A number between 0 and 9 that indicates the length, in tenths of a second, of the interval. Example: Every tenth of a second (1), every half second (5), etc.

When all information has been specified, the Interval Timer Information dialog resembles the sample dialog below:



In this example, the sec5 element's change-status flags are set to 1 every 5 seconds; that is, when the reserved analog element A_SEC = 0, 5, 10, 15, ... 55. This timer runs as if it started at midnight. Therefore, if system startup time is 9:39:18, the sec5 element's change-status flags are first set 2 seconds later, at 9:39:20, and every 5 seconds thereafter.

The sec30 element's change-status flags are set to 1 every 30 seconds, when A_SEC = 0 and 30. This timer runs as if it started at midnight.

The min7 element's change-status flags are set to 1 every 7 minutes after system startup, because 1,440 is not evenly divisible by 7.

The min20 element's change-status flags are set to 1 every hour, again at 20 minutes after the hour, and again at 40 minutes after the hour.

The report1 element's change-status flags are set to 1 every hour and 17 minutes, after system startup.

The hour8 element's change-status flags are set to 1 three times a day: at 8:00 am, 4:00 pm, and midnight, regardless of system startup time.

When interval timers are used as triggers for other tasks, such as PLC read triggers or Report Generator triggers, these tasks automatically use the change-status flags associated with these timers.

Part III

Programmable Counters

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Programmable Counters

Programmable Counters

Chapter 3 . . . .

Programmable Counters

Use the Programmable Counters task to provide count-per-unit-of-time measurements and to provide event delays, such as defining a trigger to unlock a door and then specifying a delay before the door locks again.

A programmable counter is a group of elements with values that work together to perform a count. Outputs from programmable counters can be used to provide input to Math and Logic programs or other FactoryLink tasks or to trigger Math and Logic programs.

There is no limit, except the amount of memory, to the number of programmable counters that can be defined.

The Programmable Counters task uses either the SHARED or USER domain.

The use of programmable counters requires an understanding of change-status flags. Refer to *FactoryLink Fundamentals* for this discussion.

PRINCIPLES OF OPERATION

A programmable counter is a group of elements with components that work together to perform a count. Each programmable counter is made up of some or all of the following elements and analog and digital values.

Elements

- **Enable**—triggers counting activity.
- **Up Clock**—initiates the count upward.
- **Down Clock**— initiates the count downward.
- **Clear**—resets the counted value to the starting point.
- **Positive Output**—contains the value 1 (on) when the counting limit has been reached.
- **Negative Output**—contains the value 0 (off) when the counting limit has been reached.
- **Current Value**—indicates the current value of the count.

Digital and Analog Values

- **Preset Value**—analog value that specifies the starting value.
- **Increment Value**—analog value that specifies the amount by which the count is to increase or decrease each time.
- **Terminal Value**—analog value that specifies the counting limit.
- **AutoClear**—digital value that resets the count to the starting point whenever the terminal value is reached.

Counting begins when another FactoryLink task, such as Math and Logic or EDI, writes a 1 (ON) to the Up Clock element. This triggers the Programmable Counters task to move the Current Value toward the Terminal Value by the Increment Value. If the Preset Value is less than the Terminal Value, the Increment is added to the Current Value. If the Preset Value is more than the Terminal Value, the Increment is subtracted from the Current Value.

Example One

In this example, counting is triggered to count bottles (20 per case). The Preset Value (start count) is 0, and the Terminal Value (count limit) for the number of bottles per case is 20. The Increment Value of 1 represents one bottle. When counting is triggered, each bottle counted increases the current count of bottles (starting with 0 in the case) by 1 until the case contains 20 bottles (until the Current Value reaches the Terminal Value of 20).

When the case contains 20 bottles (when the Current Value reaches the Terminal Value), the Counter task indicates the case is full by force-writing a 1 (ON) to the Positive Output element and force-writing a 0 (OFF) to the Negative Output element. At this point, if AutoClear = YES, the Current Value element is reset to 0 (the Preset Value), and the count can begin again. If AutoClear = NO, the current Value element remains at 20 (the Terminal Value), until another task writes a 1 (ON) to the clear element, indicating the count can begin again. The count does not continue past 20 (the Terminal Value). Each time the bottle count reaches 20 (the Terminal Value), the Counter task again force-writes a 1 (ON) and a 0 (OFF) to the Positive and Negative Output elements. When AutoClear = YES, or when the Clear element is triggered, the bottle count is reset to 0 (the Preset Value), ready for a repeat of the counting process.

Example Two

You can set up another task, such as EDI or Math and Logic, to react to a deviation (such as a defective bottle) during the count by adjusting the count. To adjust the count, that task writes a 1 (ON) to the Down Clock element to cause the value of the Current Value element to move toward the Preset Value by the Increment Value.

For example, during counting, if a defective bottle is counted but not packed in the case, the EDI or Math and Logic task subtracts that bottle from the total count by writing a 1 (ON) to the Down Clock element to cause the Current Value to move toward the Preset Value (0 in this example) by the Increment Value (1 in this example).

Six bottles have been counted and packed in the case. The Counter task counts the seventh bottle. But the seventh bottle is defective, so it is not packed in the case. Therefore, the EDI or Math and Logic task subtracts that bottle from the total count by writing a 1 (ON) to the Down Clock element. This causes the Current Value to move from 7 down to 6.

If all counted bottles are defective and thus are not packed, the EDI or Math and Logic task subtracts them from the total count by causing the Current Value to count down until it matches the Preset Value (0). Although the bottle count is now 0, the Output elements have not been affected and the current counting operation continues until the case contains 20 bottles.

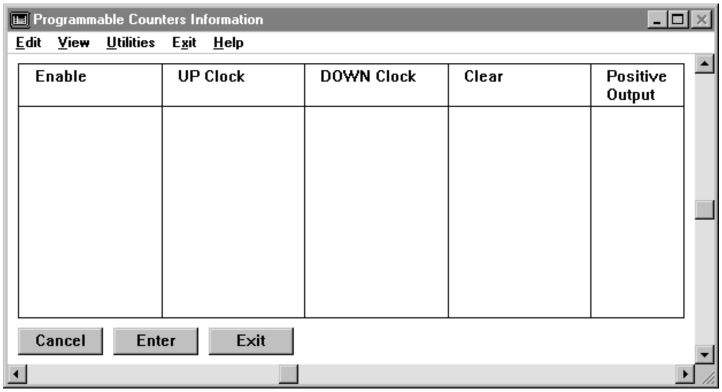
PROGRAMMABLE COUNTERS INFORMATION PANEL

The Programmable Counters task establishes parameters for the initiation, performance, and conclusion of counting activity.

The Programmable Counters task uses either the SHARED or the USER domain. We recommend the SHARED domain, unless counters should be unique to each User for the purposes of the application. Before opening and configuring the Programmable Counters task, ensure the current domain selected is SHARED in the Configuration Manager Domain Selection box.

With the “-t” program argument in the System Configuration in effect for the counter task, negative output, positive output, and current value are initialized. Positive output is set to 0. Negative output is set to 1. With no program argument, those tags remain at their default/persistent values.

Choose Programmable Counters to display the Programmable Counters Information panel. This panel contains eleven fields. Press Tab to display other fields.



Following are field descriptions for this panel.

Enable Name of an element that enables or triggers counting. If this field is left blank, counting is always enabled because the trigger becomes either the “UP CLOCK” or the “DOWN CLOCK”. When the value of Enable is set to 1 (ON), counting occurs. If the value of Enable is set to 0 (OFF), counting does not occur.

If the tag specified in this field is not already defined, a Tag Definition panel is displayed when you click on Enter with a tag type of digital in the Type field. Accept this default.

Valid Entry: standard element tag name
Valid Data Type: digital

Up Clock Name of an element that causes the value of the Current Value element (present count) to move toward the Terminal Value (count limit). When a 1 (ON) is written to the Up Clock element, the value in the Current Value element is increased by the amount specified by the Increment Value element, described below. If the Preset Value (starting count) is less than the Terminal Value, the Increment Value is added to the Current Value. If the Preset Value is greater than the Terminal Value, the Increment Value is subtracted from the Current Value.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of digital in the Type field. Accept this default.

At least one type of clock must be defined; that is, an entry is required in either the Up Clock or Down Clock field.

Valid Entry: standard element tag name
Valid Data Type: digital

Down Clock Name of an element that causes the value of the Current Value element (present value) to move away from the Terminal Value (toward the Preset Value). When a 1 (ON) is written to the Down Clock element, the value in the Current Value element is decreased by the amount specified by the Increment Value element. If the Preset Value is less than the Terminal Value, the Increment Value is subtracted from the Current Value. If the Preset Value is greater than the Terminal Value, the Increment is added to the Current Value. The Current Value does not move past the Preset Value and the Positive/Negative Outputs are not triggered when the Preset Value is reached. The data type for this tag is digital.

At least one type of clock must be defined; that is, an entry is required in either the Up Clock or Down Clock field.

Valid Entry: standard element tag name
Valid Data Type: digital

Clear — Name of an element that causes the Current Value to be reset to the Preset Value each time a 1 (ON) is written to it (the Clear element). Each time a 1 (ON) is force-written to the Clear element, a 0 (OFF) is force-written to the Positive Output element and a 1 (ON) is written to the Negative Output element.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of digital in the Type field. Accept this default.

Valid Entry: standard element tag name
Valid Data Type: digital

Positive Output — Name of an element to which a 1 (ON) is written each time the Current Value reaches the Terminal Value. The value of the Positive Output element remains 1 (ON) until a 1 (ON) is written to the Clear element.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of digital in the Type field. Accept this default.

Valid Entry: standard element tag name
Valid Data Type: digital

Negative Output — Name of an element to which a 0 (OFF) is written each time the Current Value reaches the Terminal Value. The value of the Negative Output element remains 0 (OFF) until a 1 (ON) is written to the Clear element. This tag is set to 1 at task startup.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of digital in the Type field. Accept this default.

Valid Entry: standard element tag name
Valid Data Type: digital

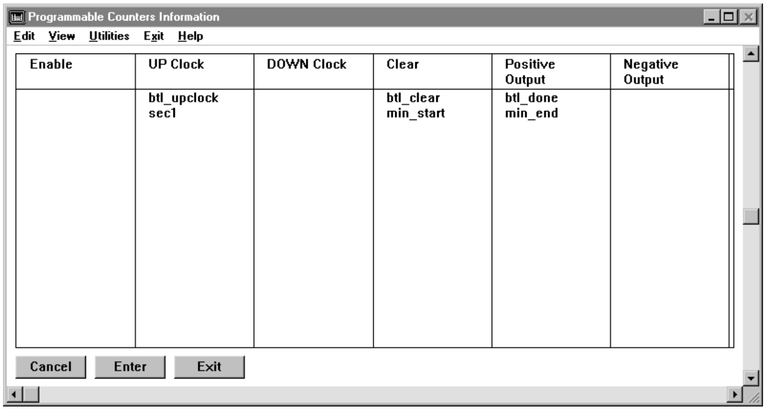
Current Value — Name of an element to specify the name of an element that contains the current value of the counter. This value is always between the Preset Value and the Terminal Value.
The default is 0.

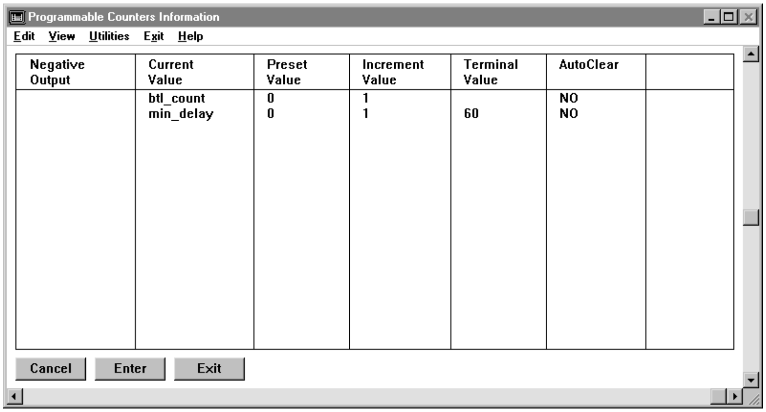
If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of analog in the Type field. Accept this default.

Valid Entry: standard element tag name
Valid Data Type: analog, longana

Preset Value	Enter a number between -32,768 and 32,767 to specify the starting value for a count. This numerical value is written to the Current Value element whenever the value of the Clear element is set to 1 (ON). The default is 0. Valid Entry: numeric value between -32,768 and 32,767 (default = 0)
Increment Value	Enter a number between 0 and 32,767 to specify the numerical value that is combined with the Current Value when the Up or Down Clock is triggered. The default is 1. Valid Entry: numeric value between 0 and 32,767 (default = 1)
Terminal Value	Enter a number between -32,768 and 32,767 to define the numerical value that specifies a limit for counting activity. When the Current Value is the same as the Terminal Value, counting stops and Positive and Negative Outputs are triggered. Counting remains stopped until the Clear element is triggered. However, if AutoClear is set, a Clear is performed immediately after the Positive and Negative Outputs are triggered. Valid Entry: numeric value between -32,768 and 32,767
Autoclear	Indicator that a Clear should be performed each time the Terminal Value is reached. This can be one of the following: YES Clear is performed each time the Terminal Value is reached. This is the default. NO Current Value remains equal to the Terminal Value until Clear is triggered.

When all information has been specified, the panel should resemble the sample below:





In the first example (first line on the panel), the counter, along with a Math and Logic procedure that saves the count and resets the counter, counts the number of bottles packed per minute. Since the Enable field is left blank, counting is always enabled. Each time a bottle is packed, a 1 (ON) is written to the Up Clock element btl_upclock. This triggers the Counter task to increase the Current Value (btl_count) by 1. Each minute, FactoryLink triggers a Math and Logic procedure to log the Current Value and trigger the Clear element (btl_clear) to reset the count for the next minute.

In the second example (second line on the panel), the counter is used to create a one-minute delay of an event, such as bottle capping. Since the Enable field is left blank, counting is always enabled. When the value of sec1 becomes 1 (ON), the Counter task increases the Current Value (min_delay) by 1. The task continues to increase this value once each second until the Current Value matches the Terminal Value of 60. At this time, counting stops and the Counter task writes a 1 (ON) to the Positive Output element min_end, indicating the end of the one-minute delay. Other FactoryLink tasks can monitor the min_end element to trigger another operation and then write a 1 (ON) to the Clear element (min_start) to reset the count.

Part IV

File Manager

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File Manager

File Manager

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File Manager

The FactoryLink File Manager task can be used to perform basic operating system file-management operations initiated by a FactoryLink application at run time. The task can work in conjunction with FactoryLink's FLLAN option to initiate operations within other FactoryLink stations on a network. The File Manager initiates the operations listed below which are performed by the operating system.

- Copy a file
- Rename a file
- Delete a file
- Print a file
- Display a directory
- Type a file

File Manager initiates these operations with six commands: COPY, REN, DEL, PRINT, DIR, and TYPE. These commands perform the same functions as their operating-system counterparts. The File Manager controls all file operations through the FactoryLink real-time database.

You can configure other FactoryLink tasks to initiate File Manager operations. For example:

- You can configure input functions in Graphics so an operator can use them to initiate file-management operations at run time, such as to display a list of recipes or reports.
- The Timer task can trigger File Manager to automatically back up files to a networked server at certain intervals, such as each day at midnight.
- The Timer task can also trigger File Manager to delete log files automatically at certain intervals, such as once every four hours, or after certain events, such as when log files reach a specified size.
- Alarm Supervisor can trigger File Manager to print alarm files.

FILE MANAGER CONTROL PANEL

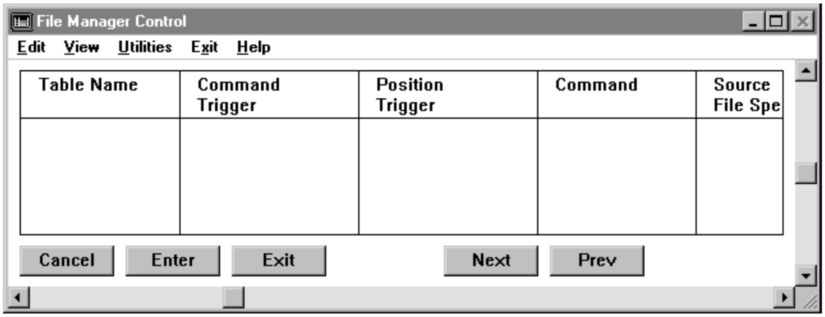
The File Manager Table has two panels.

- File Manager Control (configure one)
- File Manager Information

All operations are defined in one File Manager Control panel. For COPY, REN, DEL, and PRINT operations, do not complete a File Manager Information panel. However, for each TYPE or DIR operation defined in the File Manager Control panel, complete one File Manager Information panel.

File Manager defaults to the USER domain, but you can configure it to run in either domain. Before opening and configuring File Manager, ensure the domain selected is the correct one in the Configuration Manager Domain Selection box.

Choose File Manager to display the File Manager Control and File Manager Information panels. Complete the File Manager Control panel first:



Following are field descriptions for this panel.

Table Name (Required for TYPE and DIR operations) Enter an alphanumeric string of between 1 to 16 characters that specifies the name of the operation being defined or modified. For TYPE and DIR operations, this field connects the entry in the File Manager Control panel with the associated File Manager Information panel for that entry.

This field is optional for COPY, REN, DEL, and PRINT operations. You can use it to distinguish different operations of the same type.

Valid Entry: alphanumeric string of between 1 to 16 characters

Command Trigger
Name of an element used to initiate the file operation.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter.

Valid Entry: standard element tag name
Valid Data Type: digital, analog, longana, float, message

Position Trigger
Required only for DIR and TYPE operations; not used for COPY, PRINT, REN, and DEL operations. Name of an element whose value tells the File Manager where in a directory to start listing files, or where in a file to start typing.

The File Manager starts reading after the line number specified by the value of the Position Trigger element. For example, if the value of the Position Trigger element is 6, the File Manager begins reading the file at line seven. The number of lines displayed or the number of files listed depends on the number of Tag Name elements defined in the File Manager Information panel, described below.

You can configure the system so, at run time, you or any FactoryLink task can change the value of this element so the File Manager starts at a different point in a directory or file and shows a different subset of information.

Do not specify the same element name for DIR and TYPE operations. If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter. Accept this default.

Valid Entry: standard element tag name
Valid Data Type: analog

Command
File operation to be performed. This can be one of the following.

COPY
Copies the source file to the destination file. Specify both the source and destination paths. This operation does not require that you complete a File Manager Information panel.

REN
Renames the source file to the destination file. Specify both the source and destination paths. Both the source and destination paths must be the same; that is, they must point to the same directory. This operation does not require you complete a File Manager Information panel.

DEL	Deletes the source file. The DEL command requires only the source path; the destination path is ignored. This operation does not require you complete a File Manager Information panel.
PRINT	Causes the file specified by the source path to be printed on the device specified by the destination path. The destination path must contain the name of a device known to the Print Spooler task. This operation works only with the Print Spooler and does not require that you complete a File Manager Information panel.
DIR	Displays a list of all files in the directory specified by the source path, which can include wildcard characters. The destination path is ignored. This operation requires you complete a File Manager Information panel and you define output text objects in Graphics to display lines from the file.
TYPE	Displays the contents of the source file. The destination path is ignored. This operation requires that you complete a File Manager Information panel and that you define output text objects in Graphics to display lines from the file. Note that File Manager reads in only 80 characters at a time, and puts the rest of the line (if more than 80 characters) into the next message tag. For example, if the message in the line is 140 characters long, it puts the first 80 into the first message tag, and the next 60 into the second message tag.

Source File Spec. Full path name of the source file. The source file spec. can use the filename syntax for the operating system on which either the remote or the local station resides. If you are using FLLAN, the source can reference a remote station.

If you specify a remote station for the destination and a remote station for the source, the two remote stations must be the same. If the destination is local, there is no restriction on the source station. Similarly, if the source is local, there is no restriction on the destination. Refer to "Using the File Manager with Networks" on page 88 for information about referencing remote stations.

Type wildcard characters in the path name to show a root directory's contents using the `DIR` command. For example, in this field type:

```
C:\*.*
```

Only one file in a copy operation can be remote. Both files in a rename operation must be on the same station.

For stand-alone systems:

```
/DEVICE_NAME/DIR_NAME/SUB_DIR_NAME/FILE_NAME
```

For networked systems:

```
\\STATION_NAME\DEVICE_NAME/DIR_NAME/SUB_DIR_NAME/FILE
_NAME
```

In the case of the COPY, DEL, and DIR commands, the source file specification may contain variable specifiers or wildcard characters ("*"). Refer to "Using Variable Specifiers in File Specifications" on page 85 and "Using Wildcard Characters in File Specifications" on page 87 for more information about variable specifiers and wildcard characters.

Valid Entry: full path name

Source Variables 1-4

Names of elements whose values replace the variable specifiers in the source path name. These fields work in conjunction with the Source File Spec. field to form the path of the file to which the File Manager performs operations. The value of the element in the Source Variable 1 field replaces the first variable specifier, the value of the element in the Source Variable 2 field replaces the second variable specifier, and so on.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter.

If using variable specifiers, make the data type of the element match the variable specifier type. Refer to *FactoryLink Fundamentals* for information about variable specifiers.

Valid Entry: standard element tag name
Valid Data Type: digital, analog, longana, float, message

Destination File Spec.

Full path name of the destination file. The destination file spec. can use the filename syntax for the operating system on which either the remote or the local station resides. If you are using FLLAN, the destination can reference a remote station.

If you specify a remote station for the destination and a remote station for the source, the two remote stations must be the same. If the destination is local, there is no restriction on the source station. Similarly, if the source is local, there is no restriction on the destination. Refer to “Using the File Manager with Networks” on page 88 for information about referencing remote stations.

For stand-alone systems:

```
/DEVICE_NAME/DIR_NAME/SUB_DIR_NAME/FILE_NAME
```

For networked systems:

```
\\STATION_NAME\DEVICE_NAME/DIR_NAME/SUB_DIR_NAME/FILE
_NAME
```

Unless you use wildcard characters in the source file spec., specify the full path name of the destination. If you use wildcard characters, do not specify the full path; specify only the directory. Refer to *FactoryLink Fundamentals* for information about wildcard characters.

In the case of the COPY, DEL, and DIR commands, the destination file specification can contain variable specifiers or wildcard characters (“*”). Refer to *FactoryLink Fundamentals* for information about variable specifiers.

If using the PRINT command, use the following destination file spec. format:

```
[\\station_name\] [flags] [spool_device]
```

where

station_name	is the optional FactoryLink station name (defaults to LOCAL). The FactoryLink station name is not used on stand-alone systems.
flags	are the optional flags. This can be one of the following. NONE—This is the default. B—Binary file S—Suppress Beginning and End of File. Used to concatenate files
spool_device	is the optional spool device (defaults to 1; legal devices are 1 through 5).

Destination Variables 1-4

Names of elements whose values replace the variable specifiers in the destination path name. These fields work in conjunction with the Destination Format field to form the path of the file to which the File Manager performs operations. The value of the element in the Destination Variable 1 field replaces the first variable specifier, the value of the element in the Destination Variable 2 field replaces the second variable specifier, and so on.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter.

If you use variable specifiers, make the data type match the variable specifier type. Refer to *FactoryLink Fundamentals* for information.

Valid Entry: standard element tag name
Valid Data Type: digital, analog, longana, float, message

Completion Trigger

Name of an element used to indicate that a file-management operation is complete (not necessarily successful). This element, if entered, is set by File Manager and can be referenced by any FactoryLink task (including File Manager) to monitor file-management operations or trigger an event.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of digital in the Type field. Accept this default.

Valid Entry: standard element tag name
Valid Data Type: digital

Completion Status

Name of an element set by the File Manager task to indicate the status of an operation. The Completion Status element can be referenced by any FactoryLink task (including the File Manager) to handle file error situations or trigger the next File Manager table to start an operation.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of analog in the Type field. Accept this default.

The File Manager writes an analog value to the Completion Status element to indicate the status of a file management operation.

Use the task's TASKMESSAGE_U[6] tag to report messages on the application screen in addition to the Completion Status tag. For example, if you get a status 12 in the Completion Status tag, you also see the message: "Can't open file (path/filename)" in the tag TASKMESSAGE_U[6].

If you want to use IML for this function, set up a math procedure triggered by the status tag itself. In the procedure, assign the appropriate ASCII string for each possible status code to a message tag in a series of IF THEN statements. For example:

IF status = 1 THEN

MSG = "whatever"

ENDIF

This element can have any of the following status values:

Table 4-1

Value	Description	Value	Description
0	Operation completed successfully	12	Can't open file (path/filename)
1	Current operation in progress	13	Error occurred while reading a file
2	Specified file(s) not found	14	File could not be created
* 3	Requested a line beyond end of file	15	Error occurred while writing to a file
5	Remote system could not perform requested action	16	Illegal spool device was specified
6	Attempt to log onto a remote station failed	17	Not enough memory to perform operation
8	Network transmission error occurred	97	Illegal filename was specified

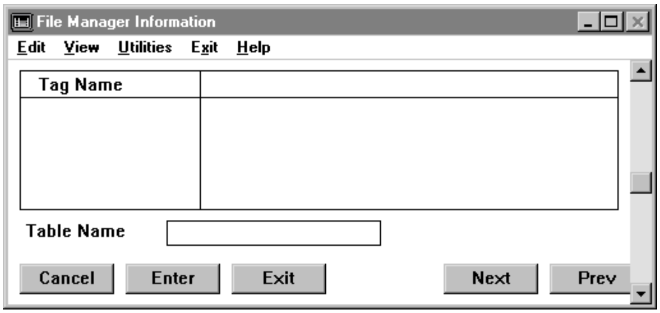
* If the TYPE/DIR position trigger offset values are increased beyond the end of the file, the File Manager will read in as many lines as possible, set the completion trigger, and set the completion status to 3.

Refer to "Sample File Manager Operations" on page 76 for examples of File Manager operations.

Valid Entry: standard element tag name
Valid Data Type: analog

File Manager Information Panel

Click Enter to save the information after completing the File Manager Control panel. Then, click Next to display the File Manager Information panel.



Following are field descriptions for this panel.

Tag Name (Required only for DIR and TYPE operations; not used with COPY, PRINT, REN, and DEL operations) Name of a message element that, as a result of a DIR or TYPE command, receives a message value to be displayed in a single line on a graphics screen. The number of Tag Name fields defined in this panel determines the number of lines displayed as a result of a DIR or TYPE command at run time.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of message in the Type field. Accept this default.

Values are written to the elements defined in the Tag Name field whenever a DIR or TYPE operation is triggered, or whenever the operator changes the value of the Position Trigger element defined in the Control panel. (A different value in the Position Trigger element means information from a different place in the directory or file is displayed.)

Click Enter to save the information when the File Manager Information panel for the specified command (DIR or TYPE) is complete.

Remember to configure one File Manager Information panel for each DIR or TYPE operation defined in the File Manager Control panel.

The File Manager Control and File Manager Information panels should resemble the illustrations shown in “Sample File Manager Operations” on page 76.

Valid Entry: standard element tag name
Valid Data Type: message

Sample File Manager Operations

The examples below illustrate each type of file-management operation. In these examples, entries for each type of file-management operation are displayed in separate sample Control panels (in a real FactoryLink application, all file-management operations are configured in one Control panel).

The first four examples do not require that you complete an associated File Manager Information panel. The last two examples do require that you complete a File Manager Information panel.

Example 1: COPY

Example 1 demonstrates how to configure a COPY operation (using Windows file syntax). You can configure the Math and Logic task or an analog counter (in the Counters task) to use this operation to increment the alarm history file number. This results in a rolling count of the history file being transferred: Hist.001, Hist.002, and so on. To configure a COPY operation, fill out the Control panel as shown below:

Table 4-2

Sample File Manager Control Panel		
Field:	**Sample Entry:**	**Explanation:**
Table Name	WINCOPY	Because the COPY operation does not require completion of the File Manager Information panel, you can leave this field blank. However, we recommend you fill in this field to distinguish different operations of the same type.
Command Trigger	copytrig	Name of the digital element that triggers the copy operation. You can configure other tasks to write to this element to trigger the copy operation.
Command	COPY	Designates a COPY operation

Table 4-2 (Continued)

Sample File Manager Control Panel		
Field:	**Sample Entry:**	**Explanation:**
Source File Spec.	c:\history\hist.%03d	The path and file name of the file to be copied. In this example, the source path name contains a variable specifier. At run time, whenever the operator or another task triggers the digital element copytrig, File Manager replaces this variable with the value of the analog element fx1_ext.
Source Variable 1	fx1_ext	At run time, File Manager replaces the variable %03d in the Source File Spec. field with the value of this analog element. In this example, this value is a three-number file extension, such as .001.
Destination File Spec.	a:\archive	The path name where the source file is to be copied. (Because this entry contains a static specifier, Destination Variables are not necessary.)
Completion Trigger	copydone	When the COPY operation has been completed, File Manager forces the value of this element to 1 (ON), indicating that the operation is complete.

Table 4-2 (Continued)

Sample File Manager Control Panel		
Field:	**Sample Entry:**	**Explanation:**

Completion Status	copystat	When the COPY operation is complete, File Manager indicates the status of the operation by writing an analog value to this element.Use the task's TASKMESSAGE_U[6] tag to report messages on the application screen in addition to the Completion Status tag. For example, if you get a status 12 in the Completion Status tag, you also see the message: "Can't open file (path/filename)."
		
		If you want to use IML for this function, set up a math procedure triggered by the status tag itself. In the procedure, assign the appropriate ASCII string for each possible status code to a message tag in a series of IF THEN statements. For example:
		
		IF status = 1 THEN
		
		MSG = "whatever"
		
		ENDIF

Example 2: PRINT

Example 2 demonstrates how to configure a PRINT operation. To configure a PRINT operation, fill out the Control panel as shown below:

PRINT command file syntax is the same for all operating systems.

Table 4-3

Sample File Manager Control Panel		
Field:	**Sample Entry:**	**Explanation:**
Table Name	PRINT	Designates the name of a PRINT operation
Command Trigger	printtrig	Name of the digital element that triggers the print operation. You can also configure other tasks to write to this element to trigger a print operation.
Command	PRINT	Designates a PRINT operation
Source File Spec.	%s	The name of the file to be printed. In this example, the file name is a variable specifier. At run time, File Manager replaces this variable with the value of the message element printpath, specified in the Source Variable 1 field.
Source Variable 1	printpath	At run time, the File Manager replaces the variable %s in the Source File Spec. field with the value of this message element. In this example, this value is a file name.
Destination File Spec.	1	1 designates the print spool device that prints the file specified by printpath. This example assumes you have already defined print spool device 1 in the Print Spooler task. At run time, when the operator or a task triggers the digital element printtrig, File Manager prints the file to Print Spooler device number one.

Example 3: REN (Rename)

Example 3 demonstrates how to configure a REN (rename) operation (using Windows file syntax). To configure a REN operation, fill out the Control panel as shown below:

Table 4-4

Sample File Manager Control Panel		
Field:	**Sample Entry:**	**Explanation:**
Table Name	WINREN	Designates the name of a REN operation
Command Trigger	rentrig	Name of the digital element that triggers the rename operation
Command	REN	Designates a REN operation
Source File Spec.	c:\temp\%s.log	This field contains a variable specifier, which File Manager replaces at run time with the value of the message element s_file, specified in the Source Variable 1 field.
Source Variable 1	s_file	At run time, File Manager replaces the variable %s in the Source File Spec. field with the value of this analog element.
Destination File Spec.	%s.tmp	%s.tmp contains a variable specifier, which File Manager replaces at run time with the value of the message element rento, specified in the Destination Variable 1 field.
Destination Variable 1	rento	When the value of the digital element rentrig is forced to 1 (ON), File Manager renames the file specified in s_file with the filename contained in rento.

Example 4: TYPE

Example 4 demonstrates the TYPE command: TYPE command file syntax is the same for all operating systems.

Table 4-5

Sample File Manager Control Panel		
Field:	**Sample Entry:**	**Explanation:**
Table Name	TYPE	Designates the name of a TYPE operation
Command Trigger	typetrig	Name of the digital element used to trigger the type operation
Command	TYPE	Designates a TYPE operation
Position Trigger	typescroll	Name of the analog element that controls the output of the TYPE command
Source File Spec.	%s	This field contains a variable specifier, which the File Manager replaces at run time with the value of the message element typepath, designated in the Source Variable 1 field.
Source Variable 1	typepath	At run time, when the value of the digital element typetrig is forced to 1 (ON), the File Manager types the file specified by typepath. Because TYPE operations do not need a destination, the Destination Variable fields are left blank.
Tag Name	typlin1 typlin2 typlin3 typlin4 typlin5 typlin6 typlin7 typlin8	At run time, when the value of the digital element typetrig is forced to 1 (ON), the File Manager reads the file specified in the Source Tag 1 element typepath. The File Manager starts reading after the line number specified by the Scroll element typescroll. In this example, eight lines of text from the specified file are read into message elements typlin1, typlin2, ...typlin8. These message elements may be referenced by other FactoryLink tasks, such as the Graphics task, for display on a graphics or text screen.

Example 5: DIR (Directory)

Example 5 demonstrates the DIR (Directory) command:

DIR command file syntax is the same for all operating systems.

Table 4-6

Sample File Manager Control Panel		
Field:	**Sample Entry:**	**Explanation:**
Table Name	DIR	Designates the name of a DIR operation
Command Trigger	dirtrig	Name of the digital element used to trigger the dir operation
Position Trigger	dirscroll	Name of the analog element that controls the output of the DIR command
Command	DIR	Designates a DIR operation
Source File Spec.	%s	This field contains a variable specifier, which the File Manager replaces at run time with the value of the message element dirpath, designated in the Source Variable 1 field.
Source Variable 1	dirpath	At run time, when the value of the digital element dirtrig is forced to 1 (ON), File Manager displays the directory specified by dirpath. Because DIR operations do not need a destination, the Destination Variable fields are blank.

Table 4-6 (Continued)

Sample File Manager Control Panel		
Field:	**Sample Entry:**	**Explanation:**
		At run time, when the value of the digital element dirtrig is forced to 1 (ON), File Manager reads the directory specified in the Source Tag 1 element dirpath. File Manager starts reading after the line number specified by the Scroll element dirscroll. In this example, eight lines of text from the specified file are read into message elements dirlin1, dirlin2, ...dirlin8. These message elements may be referenced by other FactoryLink tasks, such as the Graphics task, for display on a graphics or text screen.

Example 6: DEL (Delete)

Example 6 demonstrates the DEL (Delete) command using Windows file syntax:

Table 4-7

Sample File Manager Control Panel		
Field:	**Sample Entry:**	**Explanation:**
Table Name	WINDEL	Designates the name of a DEL operation
Command Trigger	deltrig	Name of the digital element used to trigger the delete operation
Command	DEL	Designates a DEL operation
Source File Spec.	c:\hist\%s.tmp	This field contains a variable specifier, which File Manager replaces at run time with the value of the message element delfile, designated in the Source Variable 1 field.
Source Variable 1	delfile	At run time, when the value of the digital element deltrig is forced to 1 (ON), File Manager deletes the file specified by delfile. Because DEL operations do not need a destination, the Destination Variable fields are left blank.

Using Variable Specifiers in File Specifications

If the operator or the system is to enter all or part of the source or destination specification, use variable specifiers. However, if the same files are to be used for all operations, do not use variable specifiers. Use the Source and Destination Variable fields to designate variables to replace the variable specifiers.

You can include up to four variable specifiers (each one designated by a leading percent sign %) in the path or file name. These variable specifiers indicate a portion of the path or file name that is variable (replaced with data from elements when the file operation is performed). The variables can be digital, analog, long analog, floating-point, or message elements. Multiple variables can be used together, as in a filename and extension (for example, %8s.%3s).

If you want to vary the actual path/files used in either the source or destination paths, use one or more of the four variables and %xx type specifiers to dynamically build these at run time from tags. Otherwise, simply hardcode the exact path/file names desired and leave the four tag variable fields blank.

The data type of the element must match the variable-specifier type. Variable specifiers and their data types are listed below:

Table 4-8

Variable Specifier	Variable Specifier Type	FactoryLink Data Type
%d	Decimal	Digital, Analog, Long Analog, Floating-point
%s	String	Message

Refer to *FactoryLink Fundamentals* for more information about variable specifiers.

The chart below contains examples of variable specifiers using generic syntax:

Table 4-9

Variable Specifier Examples		
Variable Description	**Entry**	**Sample Results**
Directory, subdirectory, or filename	%8s	FLINK
Numeric file extension	.%d	.1, .2, .3, etc.
	%.03d	.001, .002, .003, etc.
Filename and extension	%8s.%03d	file.001
	%8s.%3s	file.exe

Using Wildcard Characters in File Specifications

The File Manager task accepts the following wildcard character specifiers in the source and destination path names:

* (asterisk)	for string replacement
? (question mark)	for single-character replacement

Format path names as follows:

Table 4-10

source	/DEVICE_NAME/DIR_NAME/SUB_DIR_NAME/WILDCARD FILESPEC
destination	/DEVICE_NAME/DIR_NAME/SUB_DIR_NAME Do not specify a filename for the destination path with COPY as File Manager does it for you.

Path names with wildcard characters in the file specifications might resemble the following examples:

Table 4-11

source	/DEVICE/FLINK/SAMPLE/SAMPLE.*
destination	/DEVICE/FLINK/EXE

The following example is of a File Manager operation using wildcard characters (using Windows file syntax).

Table 4-12

Sample File Manager Control Panel Using Wildcard Characters		
Field:	**Sample Entry:**	**Explanation:**
Command	COPY	Designates a COPY operation
Trigger	copytrig	Name of the digital element used to trigger the copy operation

Table 4-12 (Continued)

Sample File Manager Control Panel Using Wildcard Characters		
Field:	**Sample Entry:**	**Explanation:**
Source Format	c:\hist\report\rpt*.*	Designates the source path
Destination Format	C:\HIST\RECORDS	At run time, all files in the REPORT subdirectory that begin with RPT are copied to the RECORDS subdirectory.

Using the File Manager with Networks

In addition to being fully compatible with FactoryLink, the FactoryLink File Manager is compatible with networks using the following protocol types:

- DECnet
- NETBIOS
- TCP/IP

File-management functions, such as copying, deleting, printing, and renaming files, can be performed between the local FactoryLink system and any remote computer running File Manager as long as the FactoryLink system contains the FactoryLink Local Area Networking (FLLAN) option.

If using FLLAN, create the LOCAL file before filling in the configuration tables. Define the local station name in the ASCII file LOCAL in the FLAPP/NET directory. Stand-alone systems do not require the LOCAL file.

Either the source or destination path name can refer to a file on a remote station. The format for a remote file path is as follows:

```
\\(station)\(path)
```

where

station	is the name of the remote station.
path	is the full path name of the file on the remote station.

The source and destination are interchangeable as long as one of them is the local FactoryLink station. The only difference between local file operations and remote file operations is remote file names must include the disk/drive specification (if required by the operating system) and must conform to the file name syntax for the remote computer's operating system.

In a copy operation, only one file can be remote. In a rename operation, both files must be on the same station.

For example, to copy a file from a local FactoryLink station to a remote FactoryLink station, use the following format for the remote path name:

```
\\STATION_NAME\DEVICE_NAME/DIR_NAME/FILE_NAME
```

Other file-management operations can be performed with File Manager using the same format.

Do not use the remote filename (\\(STATION)\) when performing File Manager operations on networks unless you installed FLLAN on the local and remote computers. Using the FLLAN FactoryLink station name instructs FLLAN, rather than the network, to perform the operation.

At run time, before invoking file management operations between local and remote nodes, ensure the FLFM_SERVER task is running in the SHARED domain on the remote node.

Using the COPY Command with FLLAN

COPY operations, the most common File Manager operations performed on a networked system, have the following uses.

- Copy local files to a remote station
- Copy remote files to a local station
- Copy local files to the local station

The following example is of a copy operation on a networked system. The source and destination paths are in Windows file syntax.

Table 4-13

Sample File Manager Control Panel		
Field:	**Sample Entry:**	**Explanation:**
Table Name	WINXFER	Designates a file-transfer operation on a network using FLLAN
Command	COPY	Designates a COPY operation
Trigger	filexfertrig	Name of the digital element used to trigger the copy operation
Source Format	c:\arc\%s.log	Source path where **%s** is the variable specifier. The string specified by the value of the message element s_file replaces the %s in the source specification.
Source Tag 1	s_file	At run time, File Manager replaces the variable **%s** in the Source Format field with the value of this analog element.
Destination Format	\\nod2\%s	File Manager computes the destination path in the same way as the source path.
Destination Tag 1	s_path	If the message element s_path contains the following message: `C:\FLINK\RECIPE` the computed destination specification is as follows: `\\NOD2\C:\FLINK\RECIPE`
Completion Trigger	copydone	When the COPY operation is complete, File Manager forces the value of this element to 1 (ON). This element can be used by another FactoryLink task or to trigger another File Manager operation.

Table 4-13 (Continued)

Sample File Manager Control Panel		
Field:	**Sample Entry:**	**Explanation:**
Completion Status	copystat	When the COPY operation is complete, File Manager writes the status information to this analog element.

Refer to *FactoryLink Fundamentals* for details for information about variable specifiers.

Using the COPY Command with a Network without FLLAN

When specifying a COPY command for networks without FLLAN, do not specify a station name in the Source Format and Destination Format fields. Instead, specify a network device which is any logical device on a remote computer used as if it were a local device.

Different operating systems reference network devices in different ways. To find the proper syntax for referencing these devices, consult the user's manual for the appropriate operating system.

Technical Notes

To enable a local node to perform file management operations with a remote node at run time, the FLFM_SERVER task must be running in the SHARED domain on the node that does not initiate the FLFM command. Either start the FLFM_SERVER task manually from the Run-Time Manager screen at startup or configure FactoryLink to start the FLFM_SERVER task automatically at system startup. Complete the following steps to do this.

1. Open the System Configuration Information panel in the SHARED domain from the Main Menu on the remote node.
2. Locate the row containing the entry FLFM_SERVER in the Task field.
3. Place the cursor over FLFM_SERVER.
4. Tab to the Flags field.
5. Enter an R in the Flags field. This configures the FLFM_SERVER task on the remote node to start up automatically whenever FactoryLink is started.

Operating System Notes

For Windows NT and Windows 95 Users

Configuring File Manager

Source File Spec. (5-5) andDestination File Spec (5-7).

Table 4-14

Valid Entry Format	Description	Example
DRIVE:\DIR\SUBDIR\FILE.EXT	For stand-alone systems	C:\LOG\HISTORY\HISTORY.ARC
\\STATION\DRIVE:\DIR\SUBDIR\FILE.EXT	For networked systems	\\NODE1\C:\HIST\PIC\SCREEN1.PIC

Using Wildcard Characters in File Specifications (5-17)

Format path names as follows.

Do not specify a filename for the destination path as File Manager will do it for you.

Path names with wildcard characters in the file specifications might resemble the following examples.

Table 4-15

source	C:\FLINK\SAMPLE\SAMPLE.*
destination	C:\FLINK\EXE

Using Variable Specifiers in File Specifications (5-16)

The following chart contains Windows-specific examples of variable specifiers used to designate paths. The last example shows the path name of a station on a network.

Table 4-16

Samples of Variable Specifiers in Path Names		
Description	**Example**	**Comments**
Standard path	c:\history\exe\sample.exe	Base example
1 variable	c:\%8s\exe\sample.exe	Variable for directory
2 variables	c:\%8s\%8s\sample.exe	Variables for directory and subdirectory
3 variables	c:\%8s\%8s\sample.%3s	Variables for directory, subdirectory, and 3-character file extension
4 variables	%1s:\%.8s\%.8s\ sample.%3s	Variables for drive, directory, subdirectory, and file extension
Standard path for a network station	\\node2\c:\history\exe\ sample.exe	\\node2\ is the name of a remote station

For OS/2 Users

Configuring File Manager

Source File Spec. (5-5) and Destination File Spec. (5-7)

Table 4-17

Valid Entry Format	Description	Example
DRIVE:\DIR\SUBDIR\FILE.EXT	For stand-alone systems	C:\LOG\HISTORY\HISTORY.ARC
\\STATION\DRIVE:\DIR\SUBDIR\FILE.EXT	For networked systems	\\NODE1\C:\FLINK\PIC\SCREEN1.PIC

Using Wildcard Characters in File Specifications (5-17)

Format path names as follows.

Table 4-18

source	`DRIVE:\DIRECTORY\SUBDIRECTORY\WILDCARD FILESPEC`
destination	`DRIVE:\DIRECTORY\SUBDIRECTORY`
Do not specify a filename for the destination path as File Manager will do it for you.	

Path names with wildcard characters in the file specifications might resemble the following examples.

Table 4-19

source	`C:\FLINK\SAMPLE\SAMPLE.*`
destination	`C:\FLINK\EXE`

Using Variable Specifiers in File Specifications (5-16)

The following chart contains OS/2-specific examples of variable specifiers used to designate paths. The last example shows the path name of a station on a network.

Table 4-20

Samples of Variable Specifiers in Path Names		
Description	**Example**	**Comments**
Standard path	c:\history\exe\sample.exe	Base example
1 variable	c:\%8s\exe\sample.exe	Variable for directory
2 variables	c:\%8s\%8s\sample.exe	Variables for directory and subdirectory
3 variables	c:\%8s\%8s\sample.%3s	Variables for directory, subdirectory, and 3-character file extension
4 variables	%1s:\%8s\%8s\sample.%3s	Variables for drive, directory, subdirectory, and file extension
Standard path for a network station	\\node2\c:\history\exe\sample.exe	\\node2\ is the name of a remote station

For Unix Users

Configuring File Manager

Source File Spec (5-5) and Destination File Spec(5-7).

Table 4-21

Valid Entry Format	Description	Example
/directory/subdirectory/ filename.extension	For stand-alone systems	/log/history/history.arc
\\station\/directory/ subdirectory/ filename.extension	For networked systems	\\node1\/flink/pic\ screen1.pic

Using Variable Specifiers in File Specifications (5-16)

The following chart contains UNIX-specific examples of variable specifiers used to designate paths. The last example shows the path name of a station on a network.

Table 4-22

Samples of Variable Specifiers in Path Names		
Description	**Example**	**Comments**
Standard path	/flink/exe/sample.exe	Base example
1 variable	/%s/exe/sample.exe	Variable for directory
2 variables	/%s/%8s/sample.exe	Variables for directory and subdirectory
3 variables	/%s\%s\sample.%s	Variables for directory, subdirectory, and file extension

Table 4-22 (Continued)

Samples of Variable Specifiers in Path Names		
Description	**Example**	**Comments**
Standard path for a network station	\\node2\/flink/exe/sample	\\node2\ is the name of a remote station

Using Wildcard Characters in File Specifications (5-17)

Format path names as follows.

Table 4-23

source	`/directory/subdirectory/wildcard filespec`
destination	`/directory/subdirectory`

Do not specify a filename for the destination path as File Manager will do it for you.

Path names with wildcard characters in the file specifications might resemble the following examples.

Table 4-24

source	`/flink/sample/sample*`
destination	`/flink/exe`

Part V

Print Spooler

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Print Spooler

Print Spooler

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Print Spooler

The FactoryLink Print Spooler task permits you to direct data to printers or other devices with parallel interfaces, and also to disk files.

The Print Spooler task also provides other features:

- File name spooling (loads file when print device is available, minimizing required memory)
- Management of printing and scheduling functions

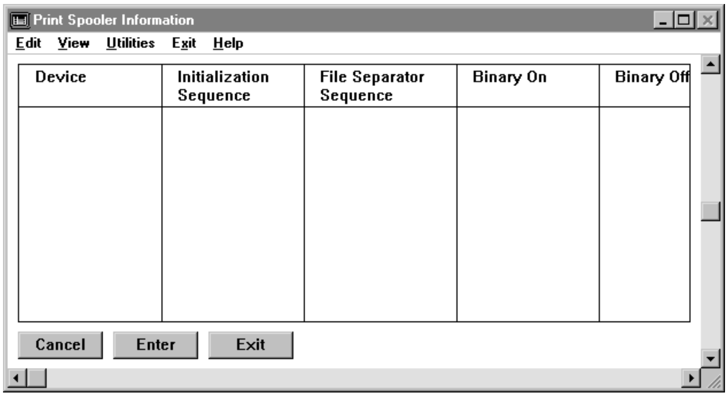
Print Spooler receives output from other FactoryLink tasks, such as Alarm Supervisor or File Manager, and sends this output to a printer or disk file.

With Print Spooler, you can define up to five devices to receive output from other FactoryLink tasks. To send files to one of these devices, FactoryLink tasks reference the corresponding device number in a configuration table.

Configuring the Print Spooler

Use the Print Spooler Table to specify the devices to which the Print Spooler task directs data. The Print Spooler Table consists of one panel: Print Spooler Information.

Print Spooler is normally configured in the SHARED domain. Before opening and configuring Print Spooler, ensure the current domain selected is SHARED in the Configuration Manager Domain Selection box. Choose Print Spooler to display the Print Spooler Information panel.



Following are field descriptions for this panel.

Device Name of the output device. Each line corresponds to a specific device number. For example, line1 = device 1 and line 5=device 5. With Print Spooler, you can define up to five devices (lines) to receive output from other FactoryLink tasks.

You can assign two or more device numbers to the same physical device. For example, if only one printer is installed and it is attached to parallel port 1, you can enter the same device name for both Device 1 (line 1) and Device 2 (line 2). Print Spooler then recognizes Devices 1 and 2 are the same physical device, and it acts accordingly.

FactoryLink tasks use the first entry in the Print Spooler Information panel as the default output device. For example, when you request a print screen in Run-Time Graphics, the output goes to the first device defined the Print Spooler panel.

You can change this default by moving the information for another defined device to the panel's first line using the cut and paste features.

You can also direct output to a file rather than to a port by specifying a path and file name. If Print Spooler writes to an existing file, the new values/text are appended to that file in the specified format.

If output is redirected to a disk file (as opposed to a true device), the file opens in append mode before it receives output. If the file does not exist when Print Spooler is first started, it is created if any print jobs are directed to it. The characters written to it are precisely the same as if it were a true device (including all device command sequences). You can use such file redirection to capture output for later examination and/or printing at a time when FactoryLink is shut down.

The Print Spooler task can send output to multiple devices at once.

The following example contains Valid entries.

Table 5-1

Operating System	Printer Specifications	Path and File Name Format
Windows NT, Windows 95, and OS/2	lpt1 COM1 lpt2 COM2 lpt3 **Note:** In OS/2 these values must be entered in lower case.	DRIVE:\DIRECTORY\SUBDIRECTORY\FILE.EXT
UNIX	/dev/ttyn or /dev/lpn where **n** is the unit number. *	/DIRECTORY/SUBDIRECTORY/FILE.EXT

Initialization Sequence/File Separator Sequence

The Initialization Sequence is defined by entering the action you want it to perform in the Initialization Sequence column of the Print Spooler Information panel. The Initialization Sequence performs the action(s) you define once at the beginning of a Spooler session.

The File Separator Sequence is defined by entering the action you want it to perform in the File Separator Sequence column of the Print Spooler Information panel. The File Separator Sequence performs the action(s) you define at the end of each file of a Spooler session.

Enter an alphanumeric string of between 1 to 16 characters for use only with the Report Generator and File Manager, not for use with the Alarm Supervisor command sequences that automatically send characters to the printers to separate the output of different files.

These command sequences can consist of two types of characters.

Display characters—Printable ASCII characters, such as A, that can be printed between files.

Control characters—Codes that instruct a printer to perform an action. Control characters have ASCII values from 00 through 1F hexadecimal. To place a control character in a sequence, enter a backslash (\) followed by the two-character hexadecimal value of the control character.

For example, to include a form feed command between files, enter the command sequences as follows (form feed has the ASCII hex value 0C):

```
Initialization Sequence:'\0C'
File Separator Sequence:'\0C'
```

The backslash character itself can be entered as two backslashes (\ \).

Refer to the user manual for the appropriate printer for information about control characters and their hexadecimal values.

Valid Entry: alphanumeric string of between 1 to 16 characters

Binary On/Binary Off Enter an alphanumeric string of between 1 to 16 characters that specifies for use only with the Report Generator and File Manager; not for use with the Alarm Supervisor command sequences sent to the printers to print binary files.

These command sequences can consist of two types of characters:

Display characters—Printable ASCII characters, such as A, that can be printed between files

Control characters—Codes that instruct a printer to perform an action. Control characters have ASCII values from 00 through 1F hexadecimal. To place a control character in a sequence, enter a backslash (\) followed by the two-character hexadecimal value of the control character.

For example, the two-digit hex value for the ASCII ESCAPE character is 1B. If, on a particular printer, an ESCAPE character followed by G turns graphics mode ON and ESCAPE followed by g turns it OFF, fill in the command sequences as follows:

```
Binary On:\1BG
```

```
Binary Off:\1Bg
```

This sequence puts the printer in graphics mode before it begins the print job and takes the printer out of graphics mode upon completion of the print job.

Valid Entry: alphanumeric string of between 1 to 16 characters

Status Tag Name of an element that contains one of three analog values representing the status of the printing device:

0	File print is complete
1	Device active
2	Error operating device

If you specify more than one device, be sure to distinguish between devices when assigning element names.

If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of analog in the Type field. Accept this default.

Valid Entry: standard element tag name

Message Tag	Name of an element that contains a message describing the status of the printing device. This element is useful if you want to display the status of a printing device on a graphics screen. To display the status of a printing device on a graphics screen, configure an output text object in the Application Editor to contain the value of this element. If you specify more than one device, be sure to distinguish between devices when assigning element names. If the tag specified in this field is not already defined, a Tag Definition dialog is displayed when you click on Enter with a tag type of message in the Type field. Accept this default.

CAUTION

All Print Spooler job requests are routed through the /FLAPP/SPOOL directory. If all such requests are not effectively transferred (for instance, if the printer is off-line), this directory can get backlogged. To ensure effective processing, check the directory periodically and delete any obsolete job requests.

Valid Entry: .standard element tag name

When you have completed the panel, it resembles the sample panel shown in the following table:

Table 5-2

Sample Print Spooler Information Panel		
Field	**Sample Entry**	**Explanation**
Device	/dev/tty1	Indicates a printer on a UNIX system.
File Separator Sequence	/0C	Is a command sequence consisting of control characters. The /0C control characters instruct printing device /dev/tty1 to insert a formfeed after each file it prints. This ensures that each file printed begins on a new page.

Table 5-2 (Continued)

Sample Print Spooler Information Panel		
Field	**Sample Entry**	**Explanation**
Status TAG	device1_status	Is an analog element containing the status of the printing device. Other tasks can read the value of device1_status to determine whether the printer is busy before they send output to it.
Message TAG	device1_msg	Is a message element containing a message about the status of the printing device. This message is displayed on a graphics screen because you also configured an output text object (in the Application Editor) to contain the value of this element.

Part VI

Math and Logic

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Math and Logic

Math and Logic

Chapter 6 . . . .

Math and Logic Overview

The FactoryLink Math and Logic task coordinates interactions among many of the FactoryLink tasks. These features include:

- Uses a structured, BASIC-like syntax
- Executes in the background with no operator intervention at run time
- Supports both interpreted and compiled Math and Logic (IML and CML)
- Supports block structures, looping constructs, and callable mathematical functions
- Supports automatic conversion of data types
- Supports multi-dimensional arrays

USES

Math and Logic is called from other applications to perform functions such as:

- Manipulate real-time database elements and local variables
- Batch control
- Performing computational calculations
- Comparing logically two values stored in database elements
- Setting the value of an element to a value chosen by an end user at run time
- Controlling the system activity resulting from end-user interaction with on-screen buttons
- Validating end-user input
- Controlling screen changes
- Controlling information flow into and out of an application

PROCEDURES

Math and Logic executes procedures containing logically grouped and organized statements that have a single continuous thread of execution, or control flow, between the decision points (branches). Typically, you analyze the actions needed in the application and organize the operations needed for each action into one or more procedures. At run time, procedures can be either:

- Triggered in response to changes in the real-time database
- Executed directly from within another Math and Logic procedure

One or more procedures are contained within an editable plain-text program file. A program (.PRG) file can contain several separate procedures that may call (or refer to) one another.

CREATING PROGRAMS

In order to use Math and Logic, you must first create a program by configuring tables.

Configuration Tables

Use the Math and Logic configuration tables to:

- Define variables used by a task.
- Identify the type of program, either interpreted or compiled.
- Identify where the programs are stored.
- Identify when a program should be invoked.

The number of elements, triggers, and programs that can be defined is limited only by the amount of available memory, operating system, and/or compiler (in compiled mode only). Refer to the documentation supplied for compiler information.

You must configure three tables to create a program.

- **Math and Logic Variables table**—Defines elements Math and Logic reads or writes. An element must be defined before it can be used in a procedure or it will be considered an undefined variable and will not validate. Define each element referenced by the procedures in a program file by entering its tag name in this table. This table has one panel: Math and Logic Variables Information.
- **Math and Logic Triggers table**—Defines the elements used to trigger the Math and Logic procedures to run. For each trigger element defined, enter the associated procedure the trigger element is responsible for triggering and the method of execution: interpreted or compiled. This table has one panel: Math and Logic Triggers Information.
- **Math and Logic Procedure table**—Writes the Math and Logic procedures required by the application. Each program file must be named exactly as it is named in the Math and Logic Triggers Information panel but with a .PRG extension. After writing a procedure and saving it to a program file name, edit it in this panel. This table is a text-entry panel: Math and Logic Procedure - *filename*.prg.

Trigger Elements

Trigger elements used in Math and Logic procedures must first be defined in the Math and Logic Variables table. Because many Math and Logic procedures can access them, these elements are global in scope. Remember: global elements are not the same as global variables which are declared inside program files and are used only within procedures. When a procedure is triggered by an element, the name of this element must be entered in the Math and Logic Triggers table so the procedure will load and run.

Completing the Tables

Complete the configuration tables in the following order.

- Math and Logic Variables table
- Math and Logic Triggers table
- Math and Logic Procedures table

Converting Previous Versions

Previous versions of Math and Logic operated in the IML mode only. Run the FLCONV utility to convert previous versions to the new one.

Opening the Configuration Manager Main Menu

Refer to *FactoryLink Fundamentals* for information on how to open the Configuration Manager Main Menu screen.

Modes

Math and Logic runs in one of two modes:

- Interpreted mode
- Compiled mode

Interpreted Mode

Interpreted mode is a subset of Compiled Math and Logic. IML means when the values of trigger elements associated with one or more procedures change in the real-time database, IML determines which procedures are affected. Math and Logic then interprets every line of the instructions and executes them for each triggered change. IML is excellent for application prototyping and logic debugging.

Most applications written in the Interpreted Mode function with no or very few modifications under the Compiled Mode. If an application running in Interpreted Mode uses any reserved words as variables or procedure names, these will need to be modified so the compiler will be able to compile and link the procedures error free. These words include any reserved by the C compiler for the platform you are running on as well as those reserved by FactoryLink.

Using IML

When you use IML, you create procedure files that are scripts and manipulate both real-time database elements and local variables.

Interpreted mode is most appropriate when:

- Only mathematical functions will be performed
- A compiler is not available

Running IML

After starting the application,

- Load the program into memory
- Validate the program
- Wait for changes to the trigger elements in the real-time database associated with the procedures in the program
- Execute the program associated with the trigger when the trigger element is set to 1 (ON)

Executing IML

When procedure changes are triggered in the real-time database, IML determines the proper procedure requested and then interprets and executes the instructions in the procedure.

Each time an IML program is executed, Math and Logic first reads, or interprets, the instructions within the program to determine the actions to perform. Then, it executes those actions.

Switching from IML to CML

To make switching from IML to CML in large applications a one-step process, use the following procedure.

From the BH_SQL prompt in the FLAPP directory of the application, issue the following command:

- To change from IML to CML, use the following command:

  SQL>update imltrig set mode = 'COMPILED' where mode is not null

- To change from CML to IML, use the following command:

  SQL>update imltrig set mode = 'INTERPRETED' where mode is not null

Compiled Mode

Compiled mode is a combination of several FactoryLink utilities with a third party ANSI C language compiler working together to generate ANSI C code from user created *.prg files.

In CML, the procedure program file is translated into C source code to create a binary executable file for the platform on which the application is developed. Because the application consists of both the SHARED and USER domains, CML creates two executable files, one for each domain. These executables are unique and are named:

- For SHARED domain:/{FLAPP}/SHARED/CML/CSHARED.EXE
- For USER domain:/{FLAPP}/USER/CML/CUSER.EXE

These files perform the same actions described in the program file when the associated trigger elements are set. CML increases the speed and functionality of applications that use IML.

Using CML

When you use CML, you make improvements on applications that use complex loops such as nested IF-THEN-ELSE clauses or WHILE loops. Interpreted mode handles the execution of arithmetic operations fairly quickly, but CML adds more functionality for you as an in-line function to pass simple parameters and as an embedded C code block to pass complicated parameters.

Compiled mode is most appropriate when you want:

- Faster startup and execution for improved performance
- Better handling of complex, multiple conditional statements
- Ability to call C functions or to insert C code into procedures
- Availability of extensive flow control for the application

Running CML

After starting the application:

- Wait for changes to the trigger elements in the real-time database associated with the procedures in the program
- Execute the program associated with the trigger when the trigger element is set to 1 (ON)

Executing CML

Each time a compiled program is executed, CML:

- Reads or interprets the instructions within the program to determine the actions to perform
- Executes these actions

CML Operation

CML uses three utilities for specific roles in creating the executables used at run time. These utilities are:

- MKCML
- PARSECML
- CCCML

MKCML

The MKCML utility is a shell that calls the PARSECML and CCCML utilities as needed for the current application. For each domain, MKCML checks the dependencies between the configuration tables and the program files by:

- Ensuring the IML.CT file is up to date by calling CTGEN. CTGEN compares IML.CT against the database files upon which IML.CT is dependent. If the database files have a later time/date stamp than IML.CT, CTGEN rebuilds IML.CT to bring them up to date.
- Checking the time/date of IML.CT to determine if the Math and Logic configuration has changed. If so, it reproduces and recompiles all of the .C files by calling PARSECML and CCCML.

When you redirect the output of MKCML to a file, the messages in the dump may appear out of order because of the way the operating system buffers and outputs messages when redirecting output. If you do not redirect the output of MKCML, the MKCML reports the messages to the standard output in the correct order.

PARSECML

The PARSECML utility parses the application program field and produces .C files for a given domain. It produces a .C file for each program file listed as compiled (has COMPILED in the Mode field) in the Math and Logic Triggers Information panel.

The utility also checks the dependencies between the program field and the .C files to determine if any procedures have been updated since the .C files were last produced.

TRIGGERING/CALLING

Triggering

Developing Triggering Schemes

Multiple procedures are executed using the triggering method of this system. To develop the most efficient triggering scheme, consider the following:

- What intervals or circumstances trigger individual procedures at a reasonable rate for this data?
- Try to use conditional event triggering based on changing data so procedures run when data is change-state driven or trigger driven.

Single-threaded Task

This task is single-threaded. This means triggered procedures are cued and executed in the order in which they are triggered. A procedure that does not complete because of an infinite loop, for example, will stop the rest of the procedures from executing.

When running one procedure, set a trigger for the next.

Calling

You can both trigger and call procedures.

Trigger Procedure: If you want to wait until one procedure has completed before executing another or if your procedure has to execute when an event occurs, trigger a new procedure.

Calling Procedure: If you want a procedure to occur immediately, you must call the procedure.

This system uses a complex cueing process that necessitates using calling procedures if you want them to occur in a distinct order.

Completing the Calling Sequence

- Enter FLRUN command
- FLRUN calls the MKCML utility
- MKCML calls PARSECML to produce .C files (C code) from the program files
- MKCML then calls CCCML to compile the .C files into object files using an external compiler and to link the object files into binary executables using an object linker.

Chapter 7 . . . .

Configuring Math and Logic

To use Math and Logic, you must first create a Math and Logic program using the three Math and Logic configuration tables:

- Math and Logic Variables table
- Math and Logic Triggers table
- Math and Logic Procedure table

This chapter describes how to configure the Math and Logic tables. The number of elements, triggers, and programs you can define is limited only by the amount of available memory, the operating system, and/or the compiler (CML only). Refer to the documentation supplied with the compiler for details on compiler limitations.

TEXT EDITOR

When working in Compiled Math and Logic, you use a text editor to select and edit information and to enter a new name.

You may also choose to create your own procedures in any text editor system for more power for some tasks. If you write your own procedures, we recommend you validate these with the FactoryLink editor.

Also, the default font size in Interpreted Math and Logic is 20 (Courier). It should be 10-12 pt (Courier). To change the default, use FLFONT. To change FLFONT, set FLFONT=12. If no Courier font exists, then default to the system fixed font.

Math and Logic Configuration Tables

The configuration of CML is completed using the same panels in the Configuration Manager used to configure IML. A new field has been added to the Math and Logic Triggers panel called the Mode field. This field controls whether the associated procedure is to be run using IML or CML. The field uses the key file *imlmode.key* to validate the field.

You may choose either Interpreted or Compiled to choose IML or CML. We suggest all procedures in an application be configured as either Interpreted or Compiled. It is possible to run both IML and CML, but the application designer must be sure that any procedures called from a Compiled procedure also be configured as Compiled.

Running FLCONV properly converts existing IML tables to the new format. Although the Mode field is blank when the application is initially converted, the default value for the field is “Interpreted” so the application may be run immediately after restoration. To convert to CML, enter “Compiled” into the Mode field of the desired procedures to Compiled.

When you name any Math and Logic objects, such as constants, variables, tags, and procedures remember that IML and CML are very sensitive to case and special characters. For CML, the unique naming is not limited to appearance in Math and Logic code but is also limited to what the name becomes in the generated C code. For example, special characters ($.*) become ‘_’ by the parsing routine. Therefore, the following declarations

declare short lu$lu

declare short lu@lu

declare short lu_lu

all become declare short lu_lu with potentially confusing results such as duplicate definition errors or changes in one variable are reflected in another. Remember when naming objects, be sure all of these objects have unique names.

.PRG Files

The .PRG files are the substance of Math and Logic. The .PRG files contain all of the procedures listed in the Math and Logic Triggers table.

.PRG Name vs Proc Name

Every .PRG file must contain one procedure defined with the same name as the eight-character portion of the filename. That procedure must be listed in the Math and Logic Triggers table. The IML task only knows which filenames to load by reading the Triggers table.

Errors that read “IML: PROC name not found” are probably caused by a typing error or failure to list a .PRG file in the Triggers table.

Procedure *names* are case sensitive while procedure *filenames* are *always* lower case (if applicable to the operating system).

PROC Definitions

A .PRG file groups several procedure definitions. Procedure definitions contain a minimum of three statements: PROC name, BEGIN, and END. Procedure definitions are case sensitive so the following defines two procedures.

```
proc Dave
begin
    print “Dave.”
end.
proc dave
begin
    print “Little Dave”
end
```

Comments

The pound sign (#) indicates the IML parser ignores a comment that is all text after the #. The exception to this is if the # is inside the string or escape using the backslash character ('\'). Well-commented code is integral to maintain a user/developer friendly code.

Math and Logic Variables Table

The Math and Logic Variables table lets you define the database elements Math and Logic reads or writes. An element must be defined before it can be used in a procedure or else the task will not validate the procedure (the element will be considered an undefined variable). Define each element referenced by the procedures in a program file by entering its tag name in this table.

The Math and Logic Variables table should contain every tag referenced in the .PRG files. Failure to list a tag in this panel results in validation errors and run-time errors. Tags listed in this panel for the SHARED domain are handled separately from the tags listed in the USER domain. For this reason, if a SHARED tag is used in both SHARED and USER procedures, it must be referenced in both the SHARED Math and Logic Variables table and the USER table.

Array tags are handled differently in this panel. To use any element of an array, only the zeroth element (array [0]) should be listed here. A common mistake is defining an array in this panel by typing array [19] to define a 20 element array. This method of definition is fine for definition purposes; but to ensure proper functioning of Math and Logic, the subscript must be changed to zero (array [0]).

This table has one panel: Math and Logic Variables Information.

Math and Logic Triggers Table

The Math and Logic Triggers table lets you define the trigger elements used to trigger the Math and Logic procedures to run. For each trigger element defined, you enter the associated procedure the trigger element is responsible for triggering.

The Math and Logic Triggers table lists a trigger tag, a procedure name, and the run mode of the procedure. Digital tags serve as the most common trigger type, but any trigger type (except mailbox) can operate as triggers. Digital tags only trigger a procedure when the value is TRUE and the change status bit is high. Other tag types trigger whenever their value changes.

This table has one panel: Math and Logic Triggers Information.

Math and Logic Procedure Table

The Math and Logic Procedure table lets you write the Math and Logic procedures required by the application. Each program file must be named exactly as it is named in the Math and Logic Triggers Information panel, but with a `.PRG` extension. After you write a procedure and save it to a program file name, you can edit it in this panel. This table is a text-entry panel: Math and Logic Procedure - *filename*.prg.

Trigger Elements

Elements used in Math and Logic procedures must first be defined in the Math and Logic Variables table. Because any Math and Logic procedure can access them, these elements are *global* in scope. (Note that global elements are not the same as *global variables* which are declared inside program files and are used only within procedures. Refer to “Structure” on page 187 in Chapter 8, “Math and Logic Syntax” for further discussion of variables and scope.) If a Math and Logic procedure is triggered by an element, the name of this trigger element must be entered in the Math and Logic Triggers table so the procedure will be loaded and run.

CONFIGURING THE MATH AND LOGIC TABLES

Complete the configuration tables in the following order:

- Math and Logic Variables table
- Math and Logic Triggers table
- Math and Logic Procedure table

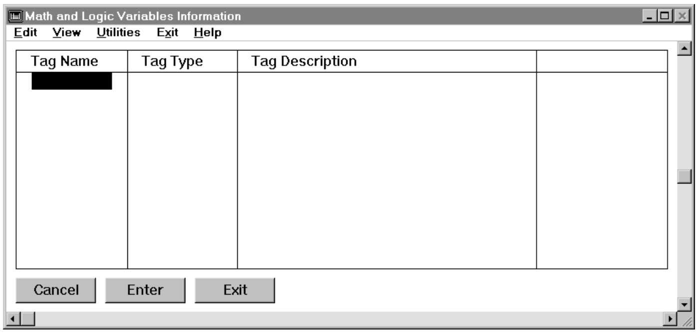
Choosing a Domain

Math and Logic can operate in either the SHARED or the USER domain. Except in cases where all tasks must share the same Math and Logic data, we recommend using the USER domain for Math and Logic in order to prevent unforeseen interference between tasks. Before opening the Math and Logic tables, ensure the current domain selected is USER in the Configuration Manager Domain Selection box. Choosing a different domain for a task after it has been configured (without making supporting changes in the application) can result in unpredictable system behavior.

MATH AND LOGIC VARIABLES TABLE

To configure the Math and Logic Variables table:

1 Choose Math and Logic Variables from the Configuration Manager Main Menu to display the Math and Logic Variables Information panel:



2 Specify the following information:

Tag Name Enter the name of an element or tag to be used in a Math and Logic procedure.

Do not use a Math and Logic reserved keyword as an element name.

If the element is to be an array, specify 0 for each array dimension when entering its name here. (For example, batch[0][0]). Then, in the Dimension field of the Tag Definition dialog, specify the number of elements for each array dimension.

Valid Entry: standard element tag name
Valid Data Type: digital, analog, longana, message

Tag Type Enter the data type of the element identified in the Tag Name field. Press ENTER for information from a predefined tag or to complete a tag.

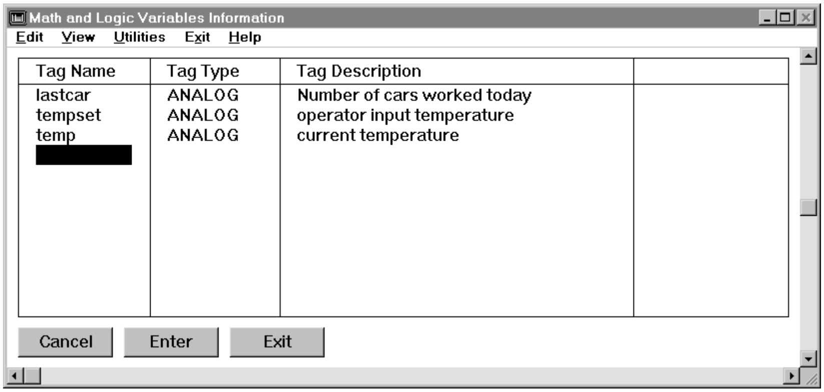
Valid Entry: data type

Tag Description Enter a description of the tag identified in the Tag Name field.

Valid Entry: standard element tag name

3 If a Tag Name field entry does not have a corresponding Tag Type field entry for tag types of digital, analog, longana, or message, a Tag Definition dialog is displayed. Choose the appropriate data type.

When you complete the configuration process, the panel resembles the following example:



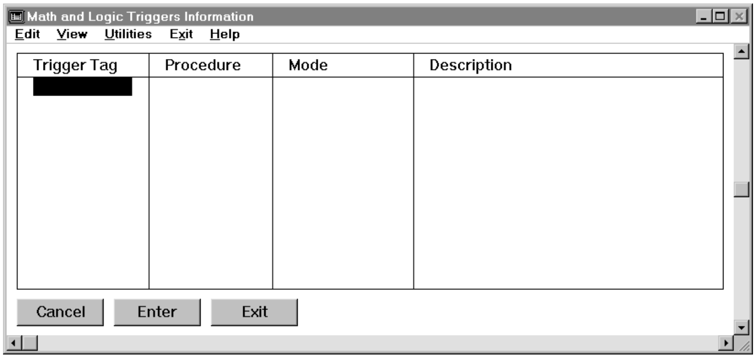
In this example, Math and Logic was configured to access the analog elements lastcar and tempset and the long analog element temp for values to use in its calculations. The tag types and tag descriptions are displayed in the panel when you click Enter.

4 After all visible fields are complete, click on Enter to save the information and return to the Main Menu.

Math and Logic Triggers Table

To configure the Math and Logic Triggers table:

1 Choose Math and Logic Triggers from the Main Menu to display the Math and Logic Triggers Information panel:



2 Specify the following information:

Trigger Tag Enter the name of an element whose value can trigger a Math and Logic procedure. The associated procedure is executed either when this element's value changes to 1 (if the element is digital) or whenever the element's value changes (for all other data types).

If there is a procedure or program file that should be loaded but does not have an associated trigger element (that is, it is invoked directly from other programs you have defined and loaded), specify the name of that file's main procedure on a separate line and leave the Trigger Tag field blank.

Valid Entry: standard element tag name
Valid Data Type: digital, analog, longana, message

Procedure Enter an alphanumeric string of between 1 to 8 characters that specifies the unique name of the Math and Logic procedure (exactly as entered in the PROC statement) to be triggered by the element defined in the Trigger Tag field. Consider the following guidelines when defining this entry:

Procedure names are case-sensitive, but the file names of the program files containing the procedures are not.

Do not give a procedure a tag name or use the same name for two procedures, even if the procedures are in different domains. If either of these two errors exist, Math and Logic cannot initiate the procedure.

Although the name of a triggered procedure cannot be longer than 8 characters, you may use longer names for procedures that are called (not triggered).

Every procedure file must contain a procedure with the same name as the file name.

The procedure name must be alphanumeric and must begin with an alphabetic character.

Valid Entry: alphanumeric string

Valid Data Type: for Windows NT, Windows 95, and OS/2: alphanumeric string of between 1 and 8 characters; for UNIX: alphanumeric string of between 1 and 16 characters (all lower case)

Mode — Enter the mode in which Math and Logic will operate. Either:

Interpreted — Math and Logic loads the associated procedure's .PRG file into memory at startup. Each time the Interpreted procedure is executed, the task interprets the procedure's instructions, and then performs the actions required.

Compiled — The original .PRG file remains unaltered. The .C file is then compiled and linked with FactoryLink and developer-supplied libraries to create the Compiled Math and Logic run-time task.

The words, Interpreted and Compiled, can be in all upper case, all lower case, or initial caps.

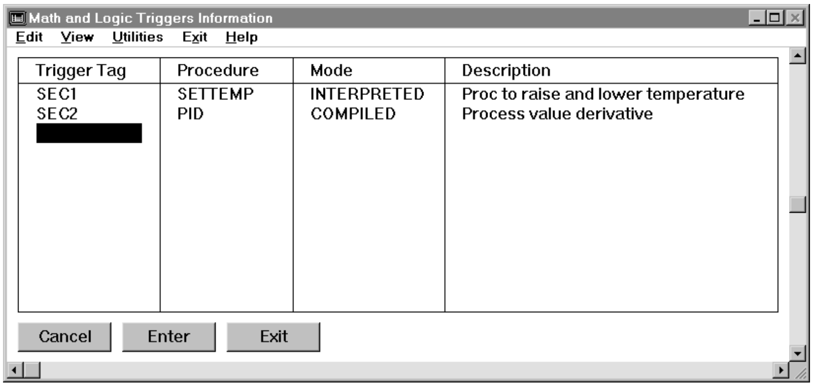
Description — Enter an alphanumeric string of between 1 to 80 characters that describes the intended use of the element specified in the Trigger Tag field.

Valid Entry: alphanumeric string of between 1 to 80 characters

3 When you have entered all the information for this panel, click Enter to save the data. If you have entered the name of any tags not already defined, the Tag Definition dialog is displayed.

4 Enter data for any tags that display in the Tag Definition dialog. Refer to the field description where the tag name is defined for details on valid tag types.

When all information is specified, the panel resembles the following example:



In this example, the Math and Logic procedure SETTEMP is run as interpreted at run time and the procedure PID is compiled at run time. When the value of trigger element SEC1 becomes 1 (ON), Math and Logic runs SETTEMP. When the value of trigger element SEC2 becomes 1 (ON), Math and Logic runs the executable for PID.

Math and Logic Procedures Table

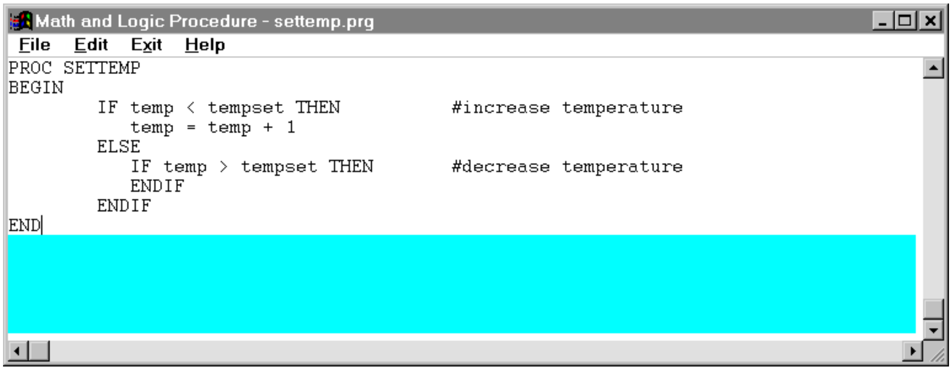
To configure the Math and Logic Procedures table:

1. Choose Math and Logic Procedures from the Main Menu to display the Select a File dialog:

2. Either choose a program to edit or enter the name of a program to create. (In this example, the program name SETTEMP was entered.) The system automatically adds the .PRG (program) extension.

3. Click Enter. The Math and Logic Procedure panel is displayed.
   - If you entered a new program name, the panel is blank.
   - If you selected an existing program, it is displayed in the panel.

Example—The program SETTEMP is shown in the panel below:



The program file SETTEMP contains a procedure named SETTEMP. The elements tempset and temp were defined in the sample Math and Logic Variables Information panel. SETTEMP is executed when the value of the trigger element SEC1 becomes 1 (ON). If the value entered for tempset is greater than the current temperature (temp), then temp is increased by 1. If the value entered for tempset is less than the current temperature, then temp is decreased by 1.

Coding Guidelines

Consider the following guidelines when coding a procedure:

- Start the procedure with a BEGIN statement and conclude it with an END statement.
- The maximum line length is 80 characters. Running a procedure with lines longer than 80 characters can cause unpredictable validation results; the procedure may validate even though there are errors. Math and Logic will not function properly while running such a procedure.
- For each IF statement, enter a matching ENDIF, properly nested.
- Show all keywords, such as IF, THEN, ELSE, and ENDIF, in uppercase characters to distinguish them from element names. (Keywords are not case-sensitive, but element names are.)

4 After you have entered the procedure, you must validate it to check for syntax errors. Choose Validate from the File menu. If there are no errors, the system reports nothing. If there are errors, the following message is displayed:

```
Canceled
Validation error.
```

5 Choose Save from the File menu to save the procedure.

6 Choose Exit to exit the Math and Logic Procedure panel and return to the Main Menu. If you try to exit a procedure containing validation errors, the following message is displayed:

```
Warning
Validation error! Select OK to continue
```

This warning reminds you errors exist so you do not run the application until the errors are corrected. A procedure that fails validation is not loaded at run time and can cause Math and Logic to fail. Exiting an empty procedure results in a validation error, however, the existence of an empty procedure will not affect the task during run time.

Correcting Validation Errors

1 Click OK from the Validation error message box. The lines of the procedure that the system could not validate turn red and the cursor moves to the first non-validated line.

2 To display error help for a non-validated line, mark the line marked as non-validated (red) and place the cursor on the line.

3 Choose Error Help from the Help menu. The system displays the cause of the error for that line.

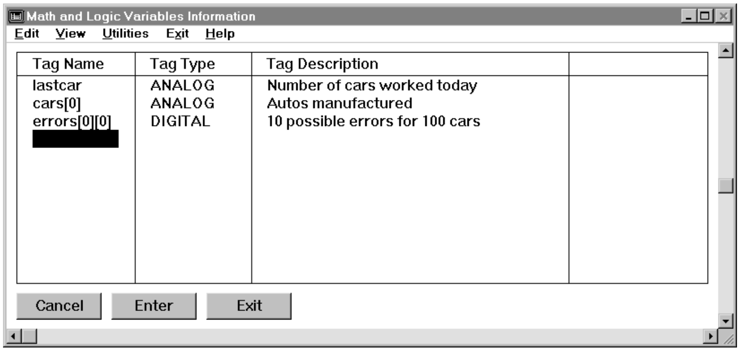
4 Choose Validate again after you have corrected an error. The system clears the red lines for that error and moves the cursor to the next non-validated line, if any.

5 Repeat Steps 2 and 3 until all errors are corrected.

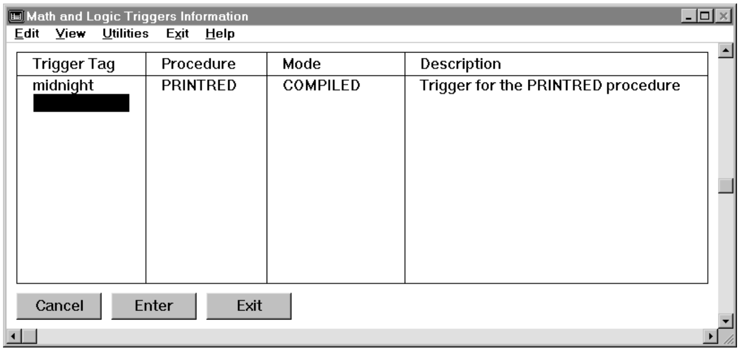
You can clear the red lines from the screen at any time by choosing Clear Err from the File menu. However, you cannot display error help.

Configuration Examples Using Element Arrays

This section shows sample Math and Logic configuration panels for an application that contains element arrays. A sample Math and Logic Variables Information panel is displayed:



The cars array stores color information about the colors of cars produced during the current run with 1 indicating a white car, 3 a red car, and so forth; the errors array contains zeroes in the first column unless a problem occurs in painting a car. Notice the array subscripts are defined to index from zero, so arrays containing 100 elements actually contain elements 0 to 99. The trigger element midnight causes the execution of the PRINTRED procedure, as defined in the sample Math and Logic Triggers Information panel:



A sample Math and Logic Procedures panel containing the procedure PRINTRED is displayed:

Math and Logic Procedure - printred.prg

File Edit Exit Help

```
PROC PRINTRED

BEGIN

# Uses element arrays cars[100], errors[10,100]
# Remember that these arrays are indexed from 0
# Declare local variables

DECLARE short r                         # Number of red cars today

# Body of procedure begins here

r=0                                     # Initially, no red cars
IF (lastcar > 99) THEN                  # We would index out of cars
    LASTCARD = 99                       # Stay within array range
    PRINT "More than 99 cars - - skipped some !\n"
ENDIF                                   # User has been notified

WHILE (r < lastcar)
    IF (cars[r] = 3) THEN               # Color no. 3 is red
        PRINT "\tAuto no. ",r," is red!\n
    ELSE
        IF (errors[1][r] THEN           # Bad paint flag is on
            PRINT "\tBad paint on auto no. ",r,"!!!\n
        ENDIF                           # Bad paint test
    ENDIF                               # Car not red
    r = r + 1                           # Look at next car
WEND                                    # While-r loop
END                                     # proc PRINTRED
```

The sample procedure PRINTRED, displayed in the panel above, is a procedure to print information about red cars. PRINTRED is executed when the value of the digital element midnight (defined in the Math and Logic Triggers Information panel) is forced to 1 (ON) at midnight of each day.

The element array cars consists of elements whose values indicate the colors cars are painted. Valid paint colors here are 1 through 5. The values of the elements in element array errors (also defined in the Math and Logic Variables Information panel) indicate whether a problem occurred with the car's paint job; a value of 0 (OFF) indicates no errors, and a value of 1 (ON) indicates a problem occurred. If a problem occurs, the element array cars will not contain a valid paint color value in that array location.

Whenever the digital element midnight is forced to 1 (ON), the PRINTRED procedure triggers Math and Logic to read the values of the real-time database message elements in the element array cars. Whenever the value of one of these message elements is 3, the value for red paint, the PRINTRED procedure tells the FactoryLink Print Spooler task to print the index into the element array cars for that car. If the car is not marked as red, the procedure tests the value of the element array error and reports an error if the value is 1 (ON). In this way, the operator receives printed information about all cars in a factory painted red each day

COMPILED MATH AND LOGIC

Compiled Math and Logic (CML) is a combination of utilities and libraries that, at run time, create binary executable files from the program files you specified to run in the compiled mode.

The compile process begins at run time when you enter the `FLRUN` command. CML translates the program (`.PRG`) files into C source code, puts the C code into files with an extension of `.C`, compiles the .C files to produce object (`.OBJ`) files, and then links the object files to the appropriate libraries to create binary executable (`.EXE`) files. Then, as each program's associated trigger is set, CML runs its executable rather than interpreting and executing the program file.

Because FactoryLink applications can be configured in two domains (USER and SHARED), CML creates one executable file for each domain in which the `.PRG` files are configured.

The file name of each executable is unique, defined to be `C` followed by the domain name:

- `/FLAPP/USER/CML/CUSER.EXE` for the user domain
- `/FLAPP/SHARED/CML/CSHARED.EXE` for the shared domain

Executable files created in the UNIX operating system do not have an extension in their file names.

7

Math and Logic

CML REQUIREMENTS

CML requires the following software and hardware:

- FactoryLink version 4.1.3 or later
- Option bits:
  - Run-time-only systems—CML run-time option
  - Development systems—CML run-time and development options
- An ANSI-compatible C-language compiler for:
  - Development systems
  - Run-time-only systems that run on an operating system different from the development system. The following table shows the supported C compilers for each operating system:

Table 7-1

Operating System	Supported Compiler
AIX	IBM AIX XL C Compiler/6000
HP-UX	HP-UX C/ANSI C
MS Windows NT	Compiler purchased with the Microsoft Visual C++ 32-bit Edition for Windows NT
OS/2	IBM VisualAge C++
SCO Open Desktop	SCO Open Desktop C

Refer to the user manual for the particular compiler in use for information about compiler switches and setup options.

Option bits:

- Development systems---the CML run-time and development options
- Run-time only systems--the CML run-time option

For Windows NT and Windows 95

Compiled Math and Logic for Windows NT and Windows 95 requires the environment variable FLCOMPILE to be set. This environment variable points to the directory of the compiler you are using.

Enter the following line in the AUTOEXEC.BAT file for Windows 95 and the Registry for Windows NT to set the FLCOMPILE environment variable.

For Windows NT:

FLCOMPILE=DRIVE:\COMPILER_DIRECTORY

For Windows 95:

set FLCOMPILE=DRIVE:\COMPILER_DIRECTORY

```
Example: set FLCOMPILE=c:\BC4
```

Entering CML Into the System Configuration Table

Before starting CML for the first time, you must enter the name of its executable file into the FactoryLink system configuration. For each domain in which you are configuring CML, you must enter the name of the applicable executable in the System Configuration Information panel.

Complete the following steps to enter the CML filename. If you configured CML to run in both domains, you must perform this procedure twice—once for each domain:

1 Open the System Configuration Information panel from the Configuration Manager Main Menu for the domain(s) in which you configured CML.

2 Enter `R` in the **Flags** field to start CML at run time.

3 Enter `CML` in the **Task Name** field.

4 Enter `Compiled Math and Logic` in the **Description** field.

5 Enter the executable name in the **Executable File** field for the domain in which you opened the System Configuration Information panel; either:

- `/FLAPP/USER/BIN/CML/CUSER.EXE` for the user domain
- `/FLAPP/SHARED/BIN/CML/CSHARED.EXE` for the shared domain

where `FLAPP` is the environment variable set to the path of the application files.

For example:

```
C:\PROCESS\USER\BIN\CML\CUSER.EXE
or
C:\PROCESS\SHARED\BIN\CML\CSHARED.EXE
.
```

Use the appropriate syntax for your operating system.

6 Click **Enter** to save the information.

7 If you are configuring CML to run in both domains, return to Step 1 and repeat this procedure for the other domain.

RUNNING CML

CML compiles and runs on both development systems and run-time systems.

Running CML on a Development System

To run CML on a development system, start the application by typing `FLRUN` at the system prompt. (Windows users must open the command line from the Program Manager using the Run option on the File menu.)

Before starting the Run-Time Manager, `FLRUN` invokes several utilities to compile programs into a single executable, the CML task (one task per domain). The compiled programs will have `COMPILED` entered in the Mode field of the Math and Logic Triggers Information panel.

Running CML on a Run-Time-Only System

To run CML on a run-time-only system, you must transfer the CML executables from the development system to the run-time system. How you do this depends on whether the development and run-time systems run on the same operating system:

If the operating system for the development and run-time system is the same, perform the following steps to run CML on a run-time-only system:

1. Use either of the following two methods to transfer the CML executables to the run-time system:
   - Use the `FLSAVE` and `FLREST` utilities to perform a platform-specific save and restore of the application from the development system to the run-time system. This saves and restores the compiled CML task along with the rest of the application.
   - Copy the executables from `/FLAPP/USER/CML` and/or `/FLAPP/SHARED/CML` on the development system to the same path on the run-time system.
2. Start CML. Depending on whether the `R` flag was set in the System Configuration Information panel, do one of the following. If the `R` flag was:
   - Set, enter `FLRUN`
   - Not set, start CML from the Run-Time Manager

The compile process begins and CML creates the executables. Because the development and run-time operating systems are the same, CML runs “as is.”

Different Development and Run-time Operating Systems

If the operating systems for the development and run-time systems are different, perform the following steps to run CML on a run-time-only system:

1. Use the FLSAVE utility to perform a multiplatform save of the application from the development system.

   Because of the different operating systems, CML will not run as originally compiled and must be recompiled either on the run-time system or on a system with the same operating system as the run-time system. A compiler is required for the system on which you will recompile CML.

2. Use the FLREST utility to perform a multiplatform restore of the application to the system on which you will recompile CML.

3. Enter FLRUN to begin the compile process during which CML creates the executables.

4. If you recompiled on a system other than the run-time system, copy the CML executables from /FLAPP/USER/CML and/or /FLAPP/SHARED/CML to the same path on the run-time system.

   CML does not recompile every time you enter FLRUN. Once CML has compiled the program files into executable files, it recompiles only if you change a program file.

HOW CML OPERATES

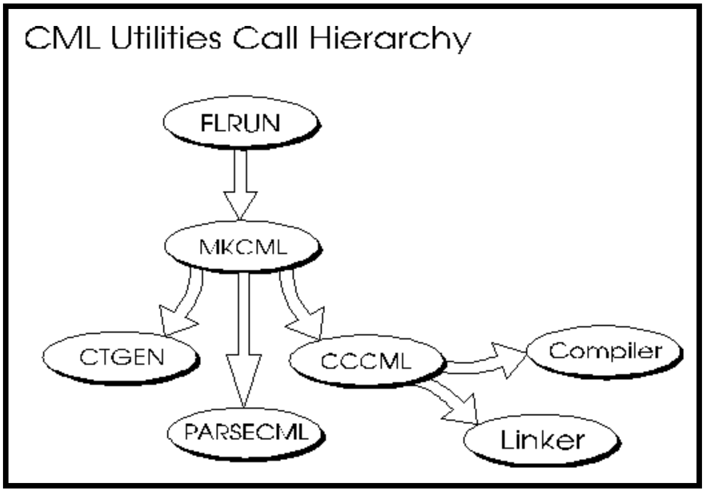
CML includes three utilities that create the executables CML uses at run time:

- MKCML
- PARSECML
- CCCML

Each utility performs a specific role in the compile process. The compile process occurs in the following calling sequence of the CML utilities, beginning at run time when you enter the FLRUN command:

1. FLRUN calls the MKCML utility.
2. MKCML calls CTGEN, which ensures the Math and Logic .CT file is up to date.
3. MKCML calls PARSECML to produce .C files (C code) from the program files.
4. MKCML then calls CCCML to compile the .C files into object files (using an external compiler) and to link the object files with library files into binary executables (using an object linker).

The following diagram illustrates the calling hierarchy of the CML utilities:



MKCML

The MKCML utility is a shell that calls the PARSECML and CCCML utilities as needed for the current application. For each domain, MKCML checks the dependencies between the configuration tables (named IML.CT for both IML and CML) and the program files. MKCML performs the following tasks:

- Calls CTGEN which compares IML.CT against the database files upon which the IML.CT file is dependent. If the database files have a later time/date stamp than IML.CT, CTGEN rebuilds IML.CT to bring it up to date.
- Determines whether the time/date of IML.CT has changed. If so, then MKCML reproduces and recompiles all of the .C files by calling PARSECML and CCCML.

When you redirect the output of MKCML to a file, the messages displayed in the dump seem to be out of order because of how the operating system buffers and outputs messages when redirecting output. If you do not redirect the output of MKCML, then MKCML reports the messages to the standard output in the correct order.

PARSECML

The PARSECML utility parses the application's program files and produces .C files for a given domain. It produces a .C file for each program file listed as compiled in the Math and Logic Triggers Information panel (has COMPILED as the Mode field entry).

This utility also checks the dependencies between the program files and the .C files to see if any procedures have been updated since the .C files were last produced.

CCCML

The CCCML utility compiles each .C file produced by PARSECML into an object file using an external compiler. It then links the object files with the FactoryLink and developer-supplied libraries into a binary executable. To determine the name of the compiler to use for a specific operating system, CCCML uses a special file called a makefile.

Running the Utilities from the Command Line

The FLRUN command sets the FactoryLink path, the application directory path, the user name, and the domain name to the environment variables and turns off the verbose-level and clean-build parameters.

CML is designed so each of the CML utilities can be started from the command line, if required. This can be useful if, during application development, you need to perform only a portion of the compile process.

The command line parameters used by all CML utilities are described in the following table:

Table 7-2 CML Command Line Parameters

Parameter	Description
`-P`	Sets the path to the FactoryLink program files.
`-A`	Sets the path to the application directory.
`-U`	Sets the user name.
`-N`	Sets the domain name.
`-V`*x*	Sets the verbose (debug) level to *x*.
`-C`	Performs a clean build, reproducing all files from scratch.

Verbose-Level Parameters

When you use a verbose-level parameter, the utility displays messages about its progress as it performs its part of the compile process. This serves as a debugging aid.

The following chart shows the messages produced by each utility at the verbose level indicated:

Table 7-3

Verbose Level	Utility	Result Displayed
1 or higher	MKCML	Application name and domains, as they are processed
1 or higherr	CCCML	—Message, "Not authorized to run Math and Logic" if the system cannot find the run-time bit —Current application and domain being processed —Message, "No .PRG files are configured as COMPILED" —Message echoing the command line that calls the compiler or linker before making the call —Names of each file as it is compiled —Message indicating all files are up to date
1	PARSECML	Name of each .C file name as it is produced
2	PARSECML	Verbose level 1 message, plus: —The comments, containing the original source lines of the Math and Logic program, placed by the utility at the start of the generated C code —All programs as they are parsed
3 or higher	PARSECML	Verbose level 1 and 2 messages, plus: —Lexical tokens from each programs as it is parsed

Makefiles

A makefile is a file containing all the information needed by the `CCCML` utility to compile the `.C` files produced by `PARSECML` and create an executable for the current domain. The name of the makefile used by `CCCML` is `CML.MAK`, and is unique for each operating system.

The `CML.MAK` file, located in the `/FLINK/CML` directory, contains the following information to create the final executable file:

- Name of the C compiler to use for a given operating system
- Command-line switches to be used when compiling
- Name of the operating system's object linker
- Linker command-line switches
- References to the FactoryLink libraries to be linked
- References to the developer-supplied libraries to be linked

Editing CML.MAK

As an aid for advanced users, CML provides a method for editing the `CML.MAK` file. You can change the compiler and linker options, specify command-line switches, and specify which object files and libraries to link, giving you the flexibility to create a makefile unique to an application for a given domain.

CML provides two options on the Main Menu for editing `CML.MAK`:

- Math and Logic System Makefile
- Math and Logic Domain Makefile

Math and Logic System Makefile

Any changes made to this file are global; they apply to all applications on the system. To edit `CML.MAK`:

1. Choose Math and Logic System Makefile from the Main Menu to display a text editor containing the CML.MAK file from the /FLINK/CML directory.
2. Edit the file as required.
3. Save and exit the file.

Math and Logic Domain Makefile

The first time you choose Math and Logic Domain Makefile from the Main Menu, an empty text editor is displayed because a domain-specific makefile does not exist. You can create one using the master makefile `CML.MAK` in the `/FLINK/CML` directory as a model. To create a domain-specific makefile:

1. Copy `CML.MAK` from the `/FLINK/CML` directory to either:
   - `/FLAPP/USER/CML` directory for the user domain
   - `/FLAPP/SHARED/CML` directory for the shared domain
2. Open the Main Menu and ensure the current domain selected in the Configuration Manager Selection box matches the domain of the makefile you are creating.
3. Choose Math and Logic Domain Makefile from the Main Menu to display a text editor containing the domain-specific makefile CML.MAK copied in Step 1.
4. Edit the file as required.

   Any definitions in the domain-specific makefile in the application directory override the definitions in the master makefile in `/FLINK/CML` directory.
5. Save and exit the file.

Advanced Concepts for CML

Utilities and Commands

CTGEN and GENDEF

CTGEN and GENDEF will run normally as part of FLRUN; but, if you are debugging and need to run the items separately, you should always run CTGEN and GENDEF before running MKCML.

MKCML Utilities

The MKCML utility coordinates the creation of the CML executables. It has three functions:

- Runs CTGEN to create to IML.CT
- Runs PARSECML (in both domains) to convert the .PRG files to .C files
- Runs CCCML to compile and link the CML domain executables

PARSECML

The PARSECML utility generates ANSI C code from each .PRG file. It have various levels of debugging via the -VX parameter that can simple generate more detailed output or even add debugging statements to the C code.

CCCML

The CCCML utility compiles and links the CML domain executables via the FLINK/CML/CML.MAK file. Its debugging levels only provide such information as the exact command line used to compile and link the code.

The FLINK/CML/CML.MAK is platform dependent and is the heart of the portability of FactoryLink. Following is an example from OS/2:

SRCSUFFIX - c

OBJSUFFIX - obj

These variables clarify the operating system/C compiler naming convention for source and object filed.

CC

The CC variable designates the command line compiler

CCFLAGS - -dos2 -AL -Au -Od -Zp -G2s -nologo -c -I{FLINK}\inc

CCFLAGS specifies all of the command line options for compiling the .C files.

CMLOBJS - glvars.obj

cmlprocs.obj

CMLOBJS are the stock CML files that are not application dependent. They are liable to change as versions change.

USEROBJS

Userobjs allows for the inclusion of user-defined object module at link time.

LINK

The LINK variable designates the command line linker.

LKFLAGS - /NOE/ST:16384/se:512

CMLLKOBJS

USERLKOBJS

These variables also allow for the inclusion of object modules not usually part of CML.

CMLLIBS - {FLINK}\LIB\FLIB.LIB

{FLINK}\LIB\CML.LIB

USERLIBS

These variables also allow for the inclusion of libraries not usually part of CML.

User-defined C language includes files that use quotes; e.g, #include “sample.h” should be placed in the {FLAPP}/{DOMAIN}/CML directory. Include files of the form #include <sample.h> should be placed in the path searched by the compiler. You may want to place them in the {FLINK}/INC directory and this is okay; however, the include files will not be saved with the application on an MPS. The best place to put the include files is in the {FLAPP}/{DOMAIN}/CML and then they will be saved with the application when an [MPS] multi-platform save is performed. If you place the include files in the latter directory, you should add the following to the cml.mak file on the line CFLAGS:

-dos2 -AL -Au -Od -Zp -G2s -nologo -c -I{FLINK}\inc -I{FLAPP}\{FLDOMAIN}\CML

DEFFILE - {FLINK}\CML\CML.DEF

This specifies the link definition file. Under some platforms it contains special information about window attributes and resources. On others, it contains compiled output options. If this is altered, it is out of the domain of USDATA technical support.

TARGET - {FLAPP}\ {FLDOMAIN}\ cm,l\c{FLDOMAIN}.exe

This is the destination executable.

CALLING C CODE

To call C code in a Math and Logic program, use the CML-specific keywords:

- cfunc
- cbegin
- cend

Using cfunc

Use the keyword cfunc to declare standard C functions and user-defined C functions as callable in-line functions within a CML program. In-line C functions allow a CML program to call a C function directly without opening a C code block. The function must be declared before it is called.

The C code generated by CML provides prototypes for standard library functions; however, it does not include prototypes for user-defined C functions. You must provide function prototypes for all user-defined functions. Including a function without a prototype may result in compiler warnings regarding the missing functions.

Use only C functions that use the Math and Logic data types of SHORT, LONG, FLOAT, and STRING with cfunc. Although a C function may use any data type internally, its interface to Math and Logic must use only these types.

In the following example, testfunc is declared to use four arguments whose values are SHORT, LONG, FLOAT, and STRING data types, and to return a value with a SHORT data type:

```
DECLARE cfunc SHORT testfunc(SHORT,LONG,FLOAT,STRING)
```

You may declare C functions to return the following data types:

Function:	Value returned:
SHORT	Short-integer
LONG	Long-integer
FLOAT	Floating-point
STRING	String
VOID	None

The VOID data type is unique to CML. Use VOID when declaring a function not required to return a value.

Do not use VOID in programs designed to run in interpreted mode.

cfunc Examples

The following two examples show how to use cfunc:

Example 1—uses cfunc to declare the standard C function strcmp() for use within a CML program:

```
DECLARE cfunc SHORT strcmp(STRING, STRING)

PROC TEST(STRING s1)
BEGIN

   IF strcmp(s1,"QUIT")=0 THEN
      PRINT “QUITTING\n”
   ENDIF

END
```

The function *strcmp()* compares two strings and returns a value that indicates their relationship. In this program, *strcmp* compares the input string `s1` to the string `QUIT` and is declared to have a return value of the data type SHORT.

- If the return value equals `0,` then `s1` is identical to `QUIT` and the program prints the message `QUITTING.`
- If the return value is less than or greater than `0,` the program prints nothing.

C functions declared using cfunc have full data conversion wrapped around them, meaning any data type can be passed to and returned from them.

Given the sample code above, the following program is legal within CML:

```
PROC MYPROC
BEGIN

DECLARE FLOAT   f
DECLARE LONG    k
DECLARE STRING  buff

   buff=strcmp(f,k)

END
```

In this program, strcmp converts the FLOAT value f and the LONG value k to strings, compares the two strings, and then returns a number (buff) that indicates whether the comparison was less than, greater than, or equal to zero. This comparison is shown below:

If f < k, then buff is a number less than 0.

If f = k, then buff is equal to 0.

If f > k, then buff is a number greater than 0.

Example 2—uses cfunc to declare the function testfunc which has a return data type of VOID:

```
DECLARE cfunc VOID testfunc(FLOAT)

PROC MYPROC
BEGIN

DECLARE FLOAT flp
   flp=100.0
   testfunc(flp)

END
```

In this program, the declared floating-point variable `flp` is set to 100.0 and this value is passed to the function testfunc. Note that VOID is entered in place of the data type for the function's return value. This is because the program is simply passing a value to testfunc and the function is not required to return a value.

Using cbegin and cend

You can use the keywords cbegin and cend to embed C code directly into a CML procedure. Between these keywords, you can call external library functions and manipulate structures and pointers Math and Logic does not support.

However, you cannot declare C variables inside a cbegin/cend block already within the scope of a procedure. When you declare a C variable, the declaration block, from cbegin to cend, must be displayed outside the procedure, above the PROC statement. (Refer to the declaration of `static FILE *Fp=stderr;` in Example 2, below.)

The cbegin and cend statement must each be on a line by itself with no preceding tabs or spaces. All lines between these two keywords (the C code block) are passed directly to the .C file PARSECML produces for this program.

The following two examples show how to use the cbegin and cend keywords.

```
# Example 1:

PROC TEST(STRING message)
BEGIN

DECLARE STRING buff

   IF message="QUIT" THEN
      PRINT “FINISHED.\n”
   ENDIF

cbegin
   sprintf(buff,"The message was %s\n",message);
   fprintf(stderr,buff);
cend

END
```

In this program, the sprintf and fprintf functions, called between cbegin and cend, are passed directly to the .C file PARSECML generates for TEST. Note that local variables are within the scope of the C code block and can be accessed during calls to external functions.

Any C code blocks outside the body of a CML program are collected and moved to the top of the generated .C file, as shown in Example 2:

```
# Example 2:

cbegin
#include “mylib.h”
cend

PROC TEST(STRING s1)
BEGIN

   PRINT “The message is ”,s1
END

cbegin
static FILE *Fp=stderr;
cend

PROC SOMETHING (FLOAT f1)
BEGIN

cbegin
   fprintf(Fp,"%6.2g\n",f1);
cend

END
```

In this program file, the statement:

`static FILE *Fp=stderr;`

will be moved to the top of the program file just after the line:

`include “mylib.h”`

The following example shows how to access real-time database elements from within embedded C code blocks. It increments the values of two analog elements, Tag1 and Tag2[5], by 10.

```
cbegin
   int fl_tagname_to_id(TAG*, int, ...); /* function
   prototype missing from CML.H*/
cend
PROC example
BEGIN
cbegin
{
   TAG tag[2];
   ANA value[2];
   fl_tagname_to_id(tag,2, “TAG1”,“TAG2[5]”);
   fl_read(Task_id,tag,2,value);
   value[0] += 10;
   value[1] += 10;
   fl_write(Task_id,tag,2,value);
}
cend
END
```

The following example shows how to manipulate message tags within embedded C code (cbegin/cend code blocks). This example reads from TAG1, adds “X” to the string, then writes the result to TAG2.

```
PROC ADD_X
BEGIN
cbegin
{
   #define MAX_LEN 80              /* default maximum
                                      message length */
   int fl_tagname_to_id(TAG*,     /* function prototype
   int,...);                          missing from CML.H */

   TAG tags[2];
   MSG tag1, tag2;
   char string_buff[MAX_LEN+1];  /* max length plus
                                      terminating 0 */
   tag1.m_ptr=tag2.m_ptr=string_buf;
   tag1.m_max=tag2.m_max=MAX_LEN;

   fl_tagname_to_id(tags,2,”TAG1”,”TAG2”);
   fl_read(Task_id,&tags[0],1,&tag1);

   strcat(string_buf,”X”);
   tag2.m_len=strien(string_buf);
   fl_write(Task_id,&tags[1],1,&tag2);
}
cend
END
```

When values are assigned to MESSAGE tags, the MAX LEN field is not transferred. As a result, all message values are truncated at 80 characters. To store values longer than 80 characters into a MESSAGE tag, the function f1_write must be called directly. The following example shows how to use a C macro to call the procedure msgtest to store a 90-character constant into the MESSAGE tag msgtag:

```
MSGTEST.PRG:

cbegin
void fl_tagname_to_id(TAG*,int,...);
#define assign_msg(tagname, value) {\
   TAG tag; \
   MSG msg; \
   char buf[] = value; \
   fl_tagname_to_id(&tag,1,tagname); \
   msg.m_ptr = buf; \
   msg.m_len = strlen(buf); \
   msg.m_max = strlen(buf)+100; /* leave plenty of room */
   fl_write(Task_id,&tag,1,&msg); \

}
cend

PROC msgtest
BEGIN

cbegin

assign_msg(“msgtag”,”12345678901234567890123456789012345678
901234567890123456789012345678901234567890123456789O”)

cend

END
```

Chapter 8 . . . .

Math and Logic Syntax

Math and Logic Syntax is the language of Math and Logic.

This chapter discusses:

- Procedure Tokens
- Reserved Keywords
- Comments
- Constants
- Structure

Procedure Tokens

Procedure tokens are word-like units recognized by the Math and Logic language. This section describes procedure tokens used in a Math and Logic program.

Naming Procedures

Local Variable Naming

```
declare short _x
```

```
declare short _counter
```

For reasons of clarity, definitions line _x should be avoided. The variable name should indicate its function within the scope of the procedure. Also, to differentiate local variables from tog variables, local variable names should start with '_'.

Referencing the type in the name of the variable is less important with local variables because the definition is near at hand.

Local variable names translate directly into the 'C' code. If you name any local variable the same as a variable or function in another module or library, you will have conflicts at compile time. The unique naming is not limited to their appearance in Math and Logic code but is also limited to what the name becomes in the generated C code. For example, special characters ($,*) become '_' by the parsing routing. Therefore, declarations like:

```
declare short lu$lu
```

```
declare short lu@lu
```

```
declare short lu_lu
```

all become declare short lu_lu with potentially confusing results such as duplicate definition errors or changes in one variable are reflected in another.

Tag Naming Conventions

These conventions are a combination of the standards used in programming and standards borrowed from existing FactoryLink applications. These conventions are necessary when using the FLDEMO application. In a genuine FactoryLink application that could have 10,000 or more different tag names, several developers, and take a year or two to complete, they are necessary.

An informative tag name should contain the following:

- Application meaning
- FactoryLink module
- Type/function
- Domain

The application meaning should be clear and concise to meet the typing requirement. The module and type portion should have standard abbreviations. The application meaning should be less than eight characters to meet the configuration environment limits.

Three major constraints exist for naming tags:

- The need for information
- The need to minimize typing
- The need for limited column widths

We recommend you create a standard column-oriented naming for the tags with fixed length fields in the name. This lets you browse a list of tags by attribute by looking for a particular column.

Math and Logic Reserved Keywords

A keyword is a word that has a special meaning in a particular programming language. Math and Logic reserves a set of keywords for use in Math and Logic programs. Because these keywords have predetermined meanings, they cannot be used as procedure names, local or global variable names, constant names, or database element names in Math and Logic.Math and Logic keywords are not case-sensitive, so you cannot use them in either case.

Math and Logic reserves use of the keywords in the following list:

MATH AND LOGIC RESERVED KEYWORDS

abs	doand	endwhile	log	setdir
add_tag	doasc	***entry***	loge	setdrive
alltrim	doband	equ	***long***	***short***
ana	dobneg	exit	lower	shutdown
and	dobor	exp	lt	short_pause
argcnt	dochr	***extern***	ltrim	***signed***
Argcount	dodiv	f2s	main	sin
Argvect	doeq	fatal	msg	***sizeof***
asc	dogetarg	fixtype	mod	sqr
asm	dogetdir dolte	fl_cmlpp	mul	***static***
auto	dogetdrive	fl_tagname_to_id	nalloc	status
begin ({)	dogt	*float*	ne	string
break	dogte	flp	nfree	***struct***
call	doinstr	***for***	not	substr
case	dolenstr	ge	or	***switch***
cbegin	dolock	getarg	pop	system
cend	dolower	getchng	popdbvar	tan
cfunc	dolt	getdir	popflp	Task_desc
changed	doltrim	getdrive	popint	Task_name
char	domod	get_entry	popstr	Task_id
check_security	domul	get_tag_types	poplong	then
chk_prot_bit	doneg	***goto***	pow	tos
chkz	doneq	gt	print	tosflp
chr	donot	i2f	proc	tosint
ckalloc	door	idl	process	toslong
clrstack	dopow	in	procnam	tosstr
cml_force_math	doprint	***if***	push	trace
cmlpp_listconst	dosetdir	include	pushdbvar	trprint
cmlpp_options	dosetdrive	init	pushflp	trim
continue	dosub	input	pushint	***typedef***
connect	dosubstr	instr	pushlong	***union***
cos	dosys	***int***	pushstr	unlock
ct_load	dotrans	l2f	***register***	***unsigned***
debuge	dotrim	l2s	resetstack	upper
declare	***double***	lana	***return***	void
default	dounlock	le	rnd	wait
dig	doupper	len	run time	wend
div	doxor	line	s2f	***while***
do	***else***	load_trig	s2i	xor
doabs	end (})	lock	savestr	
doadd	endif			

The reserved keywords in ***boldface-italic*** type are C keywords reserved by the C compiler. Program files cannot use C keywords because, when Math and Logic is running in the CML mode, it converts the programs into C source code. Other such keywords may exist. Refer to the user manual supplied with the particular C compiler in use.

The keyword `begin` is interchangeable with the opening brace ({), and the keyword `end` is interchangeable with the closing brace (}). You can use either the keyword or the brace anywhere inside Math and Logic programs.

Do not write procedures that use forms of these keywords as names because they may not be upward-compatible with later releases of Math and Logic and may cause unpredictable system behavior during execution.

COMMENTS

Comments are text used to annotate a program. Comments are not executable code and are ignored during execution. Effective commenting should be similar to effective naming. It should be clear and concise. Three areas to consider are:

- **Usage:** When defining a function, explain its purpose, what the argument types and uses are, and external side effects (or does it alter global variables or tags, and why).
- **Scope:** When defining variables, explain the scope and what procedures write to them and use their values.
- **Reference:** When you reference a function (especially if it is in a different file), note the file it is defined in and what it does to local variables.

Comments begin with the pound sign (#) and end with the end-of-line character (¶). They can be nested or written on lines by themselves. If the line of code to be annotated is short, they can be written on the same line as the code.

Always include comments in procedures for later reference. They provide programmers with information about the intended function of the procedure. Comments are also useful on variable declaration lines to explain how the variable is to be used and its value limits. Standard coding practice calls for one comment for approximately every five lines as well as at the top of any loop and before a function call.

The following example illustrates the use of comments:

```
# declare global variables
DECLARE SHORT init_flag        # decision flag
PROC EXAMPLE
BEGIN
   DECLARE SHORT _n            # declare local variables
   DECLARE SHORT tub_array[100]
   # Do initialization procedure, but only once
   init_flag = 0               # initially, init_flag = 0
   IF NOT init_flag THEN
      # Initialize database variables
      pressure == 10           # force-write pressure in
                                 product tubs
      tubs = 20                # number of tubs to fill
      tempset = 71             # degrees Celsius; "warm"
      # Set tub_array[_n] = _n for _n =0,1,...,(tubs-1)
      _n = 0                   # start loop index at 0
      WHILE _n < tubs
         tub_array[_n] = _n
         _n = _n + 1
      WEND
   init_flag = 1               # done, so set init_flag ON
   ENDIF
# Continue here with main section of procedure
# . . .
# . . .
END                            # PROC EXAMPLE
```

Constants

A constant is a numeric or character value that remains unchanged during the execution of a program. Constants can be used anywhere in a calculation a numeral can be used and are faster to use in calculations than variables.

Constants are especially useful in applications in which the boundary value of a loop or array must be modified. When the constant is modified, its value can be changed in only one place within the application, instead of in many different places.

For example, a factory upgrades from three drying beds to five and the constant BED_MAX is used as:

- A loop index--to index through the operations on the groups of beds
- An array index--for the array containing information on each bed
- As a limiting factor on the number of beds polled

The value of BED_MAX can be modified from 3 to 5, thus preventing the need for massive search-and-replace operations on hard-coded values.

Three types of constants are discussed here:

- Symbolic
- Numeric
- String

Symbolic Constants

A symbolic constant is a name you define to represent a single known numeric value. You can define a symbolic constant using either of two formats:

```
CONST name value
      or
CONST name=value
```

You can use either an equal sign or a space to separate the name and value.

For example, to define a symbolic constant PI to represent the value 3.14159, use either:

```
CONST PI 3.14159
      or
CONST PI=3.14159
```

Then you can use the constant PI wherever needed in place of the value 3.14159.

Numeric Constants

Numeric constants can be assigned to digital, analog, long analog, or floating-point elements as well as to numeric local variables. Constants can be used in expressions wherever a numeric operand (argument) is valid, provided they are not the objects of an assignment operator.

The object of an assignment is the argument on the left-hand side of an assignment operator; that is, the argument assigned a new value. Because constants cannot take on new values, they must never be placed on the left-hand side of an assignment operator. Math and Logic uses three types of numeric constants:

- Integer
- Floating-point
- Exponential

Integer constants—You can assign integer (whole number) constants to elements and local variables depending on their data types and the operation

For an element, its data type must be one of the FactoryLink data types digital, analog, or long analog and its value must be an integer.

For a local variable, its data type must be one of the local variable types short or long and its value must be an integer.

Integer constants can be represented in binary, decimal, octal, or hexadecimal notation:

Binary	Strings of 0s and 1s in which the first two characters are either 0b or 0B (to indicate base-two representation).
Decimal	Strings of any digits 0 through 9 with the first digit either non-zero, 0d or 0D (to indicate base-ten representation).
Octal	Strings of any digits 0 through 7 with the first digit a 0.
Hexadecimal	Strings containing any combinations of the digits 0 through 9 and/or the characters A through For a through f, in which the first characters are 0x or 0X (to indicate base-sixteen representation).

For example, to define the local variable _length as 28, use any of the following definitions.

Notation	**Definition**
Binary	_length = 0b11100
Decimal	_length = 28
Octal	_length = 034
Hexadecimal	_length = 0x1C

Furthermore, some values are too large to be represented as short ANALOG values and must be represented as LONGANA values. Any integer constant to be represented as a LONGANA (long integer) FactoryLink data type must be following by a trailing “L”.

The following value ranges must be represented as LONGANA values:

Notation	**Value Range**
Decimal	x < -65,536 and x > 65,535
Octal	x> 177777
Hexadecimal	x> 0xFFFF

For example, if a constant is to be larger than 65,535, place a trailing "L" after the number to indicate long analog representation, as shown below:

Notation:	Long Analog Representation:
Decimal	_upperlim = 123456L
Hexadecimal	_maxvalue = 0xFFFFFFFFL

Minimum and maximum long analog values can range between -2,147,483,647 and 2,147,483,647.

Floating-point constants—To represent floating-point constants, use standard floating-point notation or exponential notation. Floating-point constants are strings of any digits, 0 through 9, that either contain or end in a decimal point.

Exponential constants—Exponential constants are strings of any digits, 0 through 9, with an E, E-, e, or e- preceding the exponential portion of the value.

The following table shows numerals represented by numeric constants in the various notations just described:

Binary	Ob101	Ob001	Ob111
Decimal	12908	562334L	10
Octal	0123	033	05670222L
Hexadecimal	Ox45AB	OxOaOd	OX7CEFOAF4L
Floating-Point	465.95	0.0	24567.90667
Exponential	9780e12	332e-4	54221E234

String Constants

A string is a sequence of ASCII characters enclosed in double quotation marks (" "). String constants can be from 0 to 79 characters and the ending character must always be the final character in the string. For example, the string "ABC" is made up of the characters A, B, C, in that order. A string with no characters is an empty string and is a valid string. An empty string is a space enclosed in double quotation marks. If an operator enters more than 79 characters as the value of a message, the task truncates the string to include only the first 79 characters.

You can assign string constants to message-type elements or string-type local variables. Math and Logic supports operator input in both interpreted and compiled modes.

In string constants, the single backslash (\) character introduces print-formatting characters. (Print-formatting characters are shown on the following page.) The Math and Logic parser recognizes the single backslash as a signal that a print-format character (that is, an escape code) follows. Therefore, the string “\” causes a parsing error during Math and Logic processing because nothing follows the backslash. If you require a backslash within the string itself, use a double backslash (\\).

The following table lists the meanings of the print-formatting characters in Math and Logic:

Table 8-1

Character sequence	Meaning (print result)
\b	backspace
\f	form feed
\t	horizontal tab
\v	vertical tab
\\	backslash
\”	double quote
\’	single quote
\r	carriage return
\n	new line (carriage return/line feed combination; end-of-line character)

Other special ASCII characters, such as non-printing control characters (for example, the escape character), are sometimes needed as constants. Use the chr function to refer to these characters, as described in the “Technical Notes” on page 236 in Chapter 9, “Math and Logic Procedures and Functions.”

To store ASCII data, including non-printing ASCII characters, as string constants, enter the ASCII code in a call to the built-in Math and Logic function chr, which has the following format:

```
chr(xx)
```

where xx is the ASCII code to generate the character.

For example:

```
x = chr(27)   # sets the string variable x to the escape
                  character
x = chr(124)  # assigns to x the “vertical bar” symbol (|)
```

Refer to any chart of standard ASCII character codes to determine the proper ASCII value of any character. The following examples illustrate the use of string constants:

Table 8-2

Constant	Resulting String
CHR(27)	ESC character
“ABC\n”	‘A’, ‘B’, ‘C’, new line, NUL
“MENU”	‘M’, ‘E’, ‘N’, ‘U’, NUL
“\””	Double quotation mark, NUL

Use double-quotes to include special characters inside quoted strings.

Refer to the system software documentation supplied with that operating system for specialized information about ASCII characters and the details of string handling under a particular operating system (such as values of the machine’s character set).

STRUCTURE

This section describes the ways the procedure tokens can be grouped together to form declarations, expressions, statements, and directives.

Declarations

Variable declarations create storage in memory for values. A CONSTANT declaration creates a READ ONLY storage area in memory. CONST declarations store values that remain constant throughout the entire process. For example, CONST PI-3, E-2.718281828459. A DECLARE declaration creates a fully functional variable. A DECLARE variable behaves like a tag except it does not change status.

Variables can be different data types.

Declare short_counter: SHORT variables hold a signed integer whose value ranges from -32768 to 32768. SHORT local variables and analog tag variables store the same information. This is the same as a Ctype INT on most platforms (u 16 or ana value in FLIB).

Declare long_initial_time: LONG variables hold a signed integer whose values range from -32768 to 32768. LONG local variables and longana tag variables store the same information. This is the same as a C type LONG INT on most platforms (u32 or LANA value in FLIB).

Declare float_average_temp: FLOAT variables hold a 64-bit floating point value. This gives floats an 18-digit signed mantissa with a two digit signed exponent. FLOAT local variables and FLOAT tag variables hold the same format for information as the same accuracy. This is the same as a C type DOUBLE on most platforms (FLP value in FLIB).

Declare string_old_name: STRING variables are essentially arrays of shorts comprised of a maximum of 80 characters. The length of the array is dynamic and a value of zero marks the last element. STRING local variables and message tag variables are functionally the same. This is the same as a C type CHAR on most platforms. If you want to reference _worthless in another .PRG in this domain, you must put a declare short _worthless in the header of that file.

The declaration tells the procedure:

- A variable or a constant is to be created or a variable or a procedure is to be referenced.
- The scope of the created variable or constant or the referenced variable or procedure.

Scope

Scope is that part of a program in which a variable, constant, or procedure can be used. The scope of a local variable and its C code variable definition is the section of codes where this variable can be referenced. This varies according to where the declarations take place. For example,

```
FILENAME: DO_NOT.PRG

declare short_worthless

    # _worthless can be used anywhere in this domain of IML

proc do_not (short_nocount)

begin

declare short_unimportant

    #_nocount and _unimportant can only be used inside proc do_not

    worthless--_nocount + _unimportant

    #This is valid code

    call do_less

end

proc do_less

begin

declare short_wasted

declare short_space

    _wasted - worthless

          # This is valid code because _wasted is local to proc
do_less

          # and_worthless is global to this domain of IML

    _space-_unimportant

          # While this is invalid because _unimportant has not been
```

```
        # defined in proc do_less
end
```

Math and Logic uses two categories of scope: block (or local) and file (or global):

- **Block scope**—Starts at the declaration point and ends at the end of the block containing the declaration.
- **File scope**—Starts at the declaration point and ends at the end of the source file.

Generally, use a variable, constant, or procedure after its declaration point in a program.

Therefore, where variables, constants, and procedures are declared in a Math and Logic program depend on their intended scope.

Variable Declarations

Variables can be declared in a Math and Logic program as procedure variables or as elements. Variables declared as procedure variables are used to store values used only by Math and Logic to perform operations. These values cannot be used by other FactoryLink tasks because they are not stored in the real-time database. Therefore, procedure variables are not database elements.

Procedure variables declared inside a particular procedure within a file are accessible only by that procedure and are called local procedure variables.

Procedure variables declared outside of a procedure (but within its program file) are shared by all procedures in that file and are called global procedure variables.

Note that procedure variables can be of one of the following data types:

SHORT (digital)

SHORT (analog)

LONG (long analog)

FLOAT

STRING (message)

Although procedure variables are not elements in the real-time database, they are still represented in system memory and can be saved and opened repeatedly or printed during the running of those procedures that can open them.

Use the following guidelines to determine whether to declare a variable as a procedure variable or as a element:

- If the variable is opened from an external source, declare it as a database element.
- If the variable is a trigger for any procedure, it must be declared as a database element defined as a trigger element with an associated trigger tag name.
- If the variable is used only by Math and Logic and must be accessible by all of the procedures within a program file, declare the variable as a procedure variable with a global scope by declaring it outside the first procedure in the program file.
- If the variable is used only by Math and Logic and is used only within a particular procedure, declare the variable as a procedure variable with a local scope by declaring it inside that procedure.

Local Procedure Variables—Declare local procedure variables immediately after the BEGIN statement. A local variable declaration must precede all other instructions in a procedure.

Local variables are declared, one data type to a line and normally only one data item per line in statements similar to the ones shown below:

```
DECLARE short itotal
DECLARE float ftotal
```

Initialized Value— Each time a procedure is called in the interpreted mode, a new instance of each local variable is created and the value of each variable is initialized to 0. Each time the executable is run in the compiled mode, the value of each local variable is initialized to 0 which redefines the variable. When a procedure is completed, variables defined inside the procedure are destroyed.

When large numbers of local variables are declared in a program file and are meant to be accessible to all the procedures in that file, performance can be improved by placing the declarations at the top of the file in which the procedures are stored before the start of the first procedure. This makes the declarations global to the program file.

A local procedure variable may be declared as a scalar local variable or as a local array.

Scalar Local Variable—If declared as a scalar local variable, the declaration has the following form:

```
DECLARE type name
```

where

type — is one of the following:

SHORT	signed short integer
LONG	signed long integer
FLOAT	double-precision floating-point number
STRING	ASCI character string of up to 79 characters

and

name — contains only alphabetic characters (A-Z, a-z), digits (0-9), periods (.), dollar signs ($), at-signs (@), and underscores (_).

has a maximum length of 30 characters.

does not have a period as its first or last character.

does not have a digit as its first character in a name.

In the compiled mode, the periods (.), dollar signs ($), and at-signs (@) are all converted to underscores (_) in the resulting C source file.

For example, the variable names

```
.temp
```

```
$temp
```

```
@temp
```

all equal _temp when they are translated into C source code. Therefore, avoid variable names with periods, dollar signs, and at-signs.

The period (.) can be used in element tag names in this release; however, if it is used incorrectly, future software updates may produce undesirable results. In future releases of FactoryLink, the period will be used to represent an object that has its own members. Therefore, we recommend you not use the period in tag names. Contact Customer Support for additional information.

Separate the names with commas, as shown in the following example, to declare more than one variable of the same type on the same line:.

```
DECLARE SHORT _s1,_s2,_s3   # loop & array indices/3D array
```

However, we recommend variables be declared one to a line with comments on the same line after each declaration briefly describing the use of the variable.

Consider the following examples:

```
DECLARE SHORT_itotal       # total number of vats heated
DECLARE FLOAT_ftempm       # mean temperature held in vats
```

Local Array—A local variable can also be declared as a local array. A local array represents a set of values of the same type. An array is declared by specifying the size (dimension) of the array after the array type. An array can have a maximum of 16 dimensions. An array with more than one dimension may be thought of as an array whose elements are also arrays rather than scalar variables; each additional dimension gains the array another set of row and column indices. Each of the dimensions, which must be constant, are enclosed in brackets.

Use one of the following forms to declare a local variable as a local array:

```
DECLARE SHORT _week[7]         # days of the week
or
DECLARE SHORT _cal[12][31][10] # ten-year calendar array
```

The second form defines a three-dimensional array. The total number of elements in array **_**cal is the product of the size of each dimension.

Local variable arrays function like scalar local variables in many ways except neither an array nor an array element can be passed as an argument to a procedure.

Global Procedure Variables—You must declare global variables outside of any procedure that references them. How you declare them depends on whether you are running Interpreted or Compiled Math and Logic:

- For Interpreted Math and Logic, declare global procedure variables before the first procedure definition in a program file. For purposes of validation, declare global variables in each program file in which they are used. After the first invocation, they retain their values across procedure calls.

  The following model shows where you declare global and local variables:

	`# comments`
Global Variables	`DECLARE . . .# comments` `DECLARE . . .`
	`# comments`
	`PROC name`
	`BEGIN`
Local Variables	`   DECLARE . . .` `   DECLARE . . .`
	`      A = A + 1` `      A = B + 1`
	`END`

- For Compiled Math and Logic, you can declare global procedure variables in either of two ways:
  - Before the first procedure definition in a program file, as in Interpreted
  - In an include file

An include file contains all of the global variables and procedures that would otherwise be declared at the top of each program file that referenced them.

Create and edit an include file using any text editor as in the following example.

```
DECLARE PROC testproc
DECLARE SHORT val1
DECLARE FLOAT val2
```

Save the file with an .INC extension. Include files must have an .INC extension so the system can open and save them during an FLSAVE. Include files are located in the PROCS directory of the current domain and current application.

For example, the above include file is saved to the following path:

```
FLAPP\FLDOMAIN\PROCS\MYPROG.INC
```

where MYPROG.INC is a developer-defined file name.

Use the keyword include to declare the include file with any program file to be run in the compiled mode. The syntax is:

```
include “MYPROG.INC”
```

The keyword include instructs Math and Logic to read the contents of the include file and include it as part of the current program file.

Include files can be nested to a depth of 64 files to protect you from recursive includes.

The following example shows how to use an include file.

Procedures p1 and testproc without an include file:

```
Procedure p1

DECLARE PROC testproc()
DECLARE SHORT val1
DECLARE FLOAT val2

PROC p1
BEGIN

CALL testproc()

END
```

```
Procedure testproc

DECLARE SHORT val1
DECLARE FLOAT val2

PROC testproc()
BEGIN

   val1=0
   val2=0.0

END
```

Procedures p1 and testproc with an include file:

```
Include file test.inc

DECLARE PROC testproc()
DECLARE SHORT val1
DECLARE FLOAT val2
```

```
Procedure p1

include "test.inc"

PROC p1
BEGIN

CALL testproc()

END
```

```
Procedure testproc

include "test.inc"

PROC testproc()
BEGIN

    val1=0
    val2=0.0

END
```

Constraints on using variables—Variables declared inside a procedure must have different names from variables declared outside of a procedure. The case of a variable name is significant.

- A variable name cannot begin with a digit (0-9).
- Variables cannot be initialized at declaration.
- Arrays cannot be passed as arguments to a procedure, but individual array elements can.

Constant Declarations

Constants are shared by all procedures and must be declared before any procedure in which they are used. Therefore, place constant declarations above the procedure statement of the first procedure within the program file in which the constant is referenced.

Only one constant can be declared on each line.

Procedure Declarations

A procedure declaration identifies a procedure either defined later in the current program file or is referenced (called) by a procedure in the current program file. It is comparable to a forward reference in the Pascal programming language used when a procedure calls another procedure not yet encountered but already exists.

Use one of the following forms to declare a procedure depending on whether or not the procedure will accept arguments:

```
DECLARE PROC name

or

DECLARE PROC name (type[,type])
```

If a procedure is to take arguments, use the second form given above. Only the data type of each argument is given in a procedure declaration. The data type of each argument is the same as the original local variable (SHORT, LONG, FLOAT, STRING).

The number of arguments in the declaration, the order in which the arguments are entered, and their data type must match the procedure definition. Refer to “Procedures” on page 232 in Chapter 9, “Math and Logic Procedures and Functions” for more information about arguments.

Remember procedure declarations are convenient when a custom-written procedure must refer to another custom-written procedure not yet been encountered because it is contained within another program file or occurs later in the same program file.

When the procedure being called is displayed in the same file but before the current procedure, procedure declarations are not required.

The following example shows how procedure declarations affect procedure calls:

`PROC A`
`BEGIN`
`.`
`.`	

`CALL B`
`.`
`.`
	Because Procedure B has not been declared and does not appear before Procedure A, this call is not allowed. Procedure B must be declared.

`END`
`PROC B`
`BEGIN`
`.`
`.`	

`CALL A`
`.`
`.`
	Because Procedure A is displayed before Procedure B, this call is allowed.

`END`	

Using the same example, by declaring PROC B above the definition of PROC A, then PROC B can be called:

`DECLARE PROC B`	Declare PROC B.

`PROC A`
`BEGIN`
`.`
`.`	

`CALL B`
`.`
`.`
	PROC B can be called here because it was declared previously.

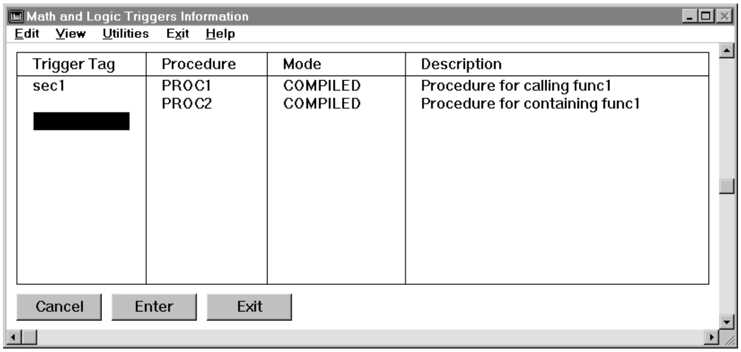
`END`
`PROC B`
`BEGIN`
`.`
`.`
`CALL A`
`.`
`.`
`END`	

You can also call a procedure or function defined in another program file. If no triggered procedures exist in the referenced program file, then the Math and Logic Triggers table must contain an entry for that file. In the example below, Func1 is called in PROC1.PRG, but it is defined in PROC2.PRG. Therefore, PROC2 requires an entry in the Math and Logic Triggers Table.

```
PROC1.PRG

DECLARE PROC func1
PROC PROC
BEGIN
  .
  .
  .
CALL func1
  .
  .
  .
  .
END
```

Func 1 is called in PROC1.PRG, but it is defined in PROC2.PRG. Therefore, PROC2 requires an entry in the Math and Logic Triggers Table.

```
PROC2.PRG

PROC PROC2
BEGIN
  .
  .
  .
END

PROC func1
BEGIN
  .
  .
  .
END
```



Data Types and Variable Types

Because Math and Logic supports both elements and procedure variables, procedure variables can be defined as any of the FactoryLink data types.

The table below shows the FactoryLink data types and their corresponding variable types:

Table 8-3

FactoryLink Data Types	Procedure Variable Types
DIGITAL	short
ANALOG	short
LONGANA	long
FLOAT	float
MESSAGE	string
MAILBOX	N/A

Floating-point data items conform to ANSI double-precision standards. The FactoryLink data type MAILBOX has no counterpart in Math and Logic. MAILBOX data types cannot be defined as local procedure variables.

Use the following guidelines to choose which data type to use in a particular instance:

- If the value will ever need to maintain a fractional portion (to the right of the decimal point), define it as a FLOAT (floating-point).
- If it is a flag or an ON-OFF type of decision point, declare it as a DIGITAL (this is analogous to the boolean or logical data types in other programming languages).
- If it is an integer within the defined range of the machine, declare it as either an ANALOG (if it fits in the “short” range) or a LONGANA (long analog) (if it will not fit in the short range, but is still expected to be within the stated allowable range for integers). Integers are numbers without a fractional portion.
- Declare text variables to be written to the screen or to a file as MESSAGE.

For Windows NT and Windows 95

The 64K barrier under segmented architectures such as Microsoft Windows NT and Windows 95 presents a limitation on the size of some variable data in Math and Logic. Neither global nor local variable arrays or data items (such as string arrays or message/buffer data, both of which tend to become large) may exceed 64K. Items declared larger than 64K will, nevertheless, be allocated only 64K under Microsoft Windows; no compile-time or panel-entry checking is planned to limit the size of declarations because of the multi-platform nature of the current FactoryLink software system. Note also that the index (sizing) value for a variable array is limited to 32K (32,767); array dimensions must be declared so as not to exceed this limit.

Note these limitations when planning application data design; in other words, any global or local variables which must be larger than 64K to serve the needs of the application designer should be partitioned logically during design so no data item as declared exceeds 64K. Contact Customer Support for suggestions on workarounds (such as declaring several linked data items) if large buffers are needed in an application.

For OS/2

The 64K barrier under segmented architectures such as OS/2 presents a limitation on the size of some variable data in Math and Logic. Neither global nor local variable arrays or data items (such as string arrays or message/buffer data, both of which tend to become large) may exceed 64K. Items declared larger than 64K will, nevertheless, allocated only 64K; no compile-time or panel-entry checking is planned to limit the size of declarations because of the multi-platform nature of the current FactoryLink software system. Note also that the index (sizing) value for a variable array is limited to 32K. Declare array dimensions that do not exceed this limit.

Note these limitations when planning application data design; in other words, any global or local variables which must be larger than 64K to serve the needs of the application designer should be partitioned logically during design so no data item as declared exceeds 64K. Contact Customer Support for suggestions on workarounds (such as declaring several linked data items) if large buffers are needed in an application.

For UNIX

The size of global and local data declared is limited only by the amount of available memory available to the task running under UNIX. However, if the application is to be ported back down to a segmented architecture, such as OS/2, the 64K barrier presents a limitation on the size of some variable data in ML. In procedures to be ported later to an OS/2 system, global and local variable arrays or data items (such as strings or message/buffer data, which tend to become large) should be partitioned so no data item as declared exceeds 64K. Also note that the index (sizing) value for a variable array under OS/2 is limited to 32K (32,767); if software is to be portable, array dimensions must be declared so as not to exceed this limit. The limit under UNIX is normally 64K (65,534), depending on the amount of free memory allocated to the run-time process.

Note this limitation when planning application data design for such applications. Contact Customer Support for suggestions on workarounds (such as declaring several linked data items) if large buffers are needed in an application to be ported.

Data Type Conversion

Create a new variable of a particular data type for accuracy in computation, such as floating-point, and initialize the new item to the current value of another variable of a different data type, such as a long analog. This conversion prevents a possible loss of accuracy in upcoming calculations, as explained below. Use the new variable to do operations with other variables of the same type as the new variable.

Automatic conversion of any numeric data type (digital, analog, long analog, or floating-point) takes place when a variable of one type is assigned the value of another variable of a different data type. Use the simplest type of assignment statement necessary for the conversion to obtain the most efficient performance. Refer to “Statements” on page 220 for information about assignment statements.

Include the new variable in a configuration table or in a program file (depending on whether the original variable is a element or is local to program operations). This will greatly simplify the debugging process should a problem occur during startup.

Data type conversions are not often needed, but they can be useful in particular situations. Convert variables whenever the result requires the accuracy of the most precise data type involved or when incompatible operations are taking place between digital and analog values. Data type conversion can ensure the accuracy of the results of certain calculations with a few exceptions. The following guidelines indicate when and why data types should be converted.

Guidelines for Converting Data Types—

Floating-point truncation — If a floating-point value is assigned to a digital, analog, or long analog variable, Math and Logic truncates the fractional part of the floating-point value instead of rounding it up or down before assigning the value to the variable. This results in a loss of accuracy. This may be acceptable when the fractional values are not significant in the result of the calculation.

Non-zero conversion — Assigning an analog, long analog, or floating-point value to a digital variable converts any non-zero value to 1 and returns 0 if the value is 0. This can be useful when all one needs to know is whether a particular variable's contents are non-zero (for use as a trigger element, perhaps), but it can result in a loss of precision in other situations. Because a digital data type holds only a single bit of data, the operation has only two possible results: if the assigned value is 0 after any fractional part is truncated, the digital variable takes on a value of 0; if the assigned value is non-zero after any fractional part is truncated, the digital variable takes on a value of 1.

Floating-point conversion — Assigning a floating-point value to an analog or long analog variable can result in a loss of precision [loss of least-significant bit(s)] when the system truncates the fractional portion of the value. The integer portion of the floating-point value might also exceed the maximum number of bits allocated to an integer which causes an overflow in the analog element.

The maximum number of bits used by an integer depends on the data type of the element or variable. Data types and maximum number of bits are as follows:

Table 8-4

Data Types:	Maximum Number of Bits:
SHORT (analog)	16
LONG (long analog)	64
FLOAT (floating-point)	64

Data type precision When numeric data types are used in arithmetic operations (+, -, *, /), the result has the precision of the most accurate data type. If either data type is floating-point, the result is floating-point. Otherwise, the result is analog. Digital and analog data types are internally represented as signed integers.

Overflow Execution of arithmetic operations can result in an out-of-range value being placed into an analog or float variable. This results in a condition known as overflow [loss of most significant bit(s)] in that variable.

To avoid causing overflow, do not use calculations in your application that divide very small numbers by very large numbers, those that divide very large numbers by very small numbers, or those that divide a number by zero.

We recommend you test for integer overflow (analog values) conditions and for floating-point overflow (float values) conditions. It is important before performing computations, ensure the results will be within the stated maximum and minimum ranges of the system itself. However, if you need to use larger analog values than the system can handle, use floating-points as a workaround; situations requiring numbers larger than the float representations possible on most systems will almost never arise.

Short to long analog conversion Short analog values are simple to convert to long analog values. The first example below shows how overflow conditions on long analog values can be corrected by converting the values to floating-point prior to attempting the computation in which errors are likely to occur. The second example shows a workaround for floating-point overflow conditions.

Long analog value overflow correction—If temp is a 16-bit analog variable that currently has the value 30,000, then (because of the limitations inherent in representing numbers in the computer) the erroneous result of the computation 2Xtemp will be -5,536, instead of the expected value of 60,000. In other words, the result of this computation does not fit into the integer field allocated to the analog variable, but it is not automatically converted to floating-point. If you anticipate working with large values such as this or detect their presence during the execution of a program, it would be wise to provide for the conversion of the value. Force this conversion by creating a floating-point variable fptemp and setting fptemp = 2.0Xtemp.

Floating-point value overflow correction—Although it is rare, overflow conditions can also occur in operations on floating-point data types. The result of an overflow is unpredictable and usually fatal; therefore, set up the programs to detect and avoid overflow conditions. For example, division by zero always results in overflow. If this happens, modify the programs involved so any variable about to be used as a divisor is tested for zero and provide for a method to skip the operation (or to write an alert message) whenever these conditions arise. If overflow occurs, check string concatenation (joining) operations to determine if they are resulting in the assignment of inappropriate strings to floating-point values. This is discussed in String conversion below and in Example 4 on page 206.

String conversion

A string type can be used in an arithmetic or logical operation if and only if the string is a sequence of digits (including the natural logarithm constant e, as noted below). The string is converted to a number before the operation is performed; conversion stops at the first non-numeric character (except e). A string can be from 0 to 79 characters. If an operator enters more than 79 characters as the value of a message, the task truncates the string to include only the first 79 characters.

String-to-numeric conversion stops at the first non-numeric character. In general, when alphabetic characters are used inside a string that contains only numeric data, the task sometimes interprets the characters differently from the way you intended. We recommend you set up some type of input checking if strings are to be routinely accepted as operands for computations.

A special case is when the letter “e” is included inside the string. During string conversion, “e” is interpreted as exponential, an indication the string of digits is to be considered written in scientific notation. Refer to “Numeric Constants” on page 182 for information about numeric representation. This allows the representation of larger numbers in a more compact format. It can, however, cause problems if you have not planned for limits on the type, number, and location of alphabetic characters inside these strings, and if you do not invoke logic to test the contents of the string for appropriateness before calling the conversion routine. (For an example, and a description of the resulting workaround, see Example 4 on page 206.)

If the "+" (plus) operator is used in an expression with an operand of the string type, the other operand in the expression will be automatically converted to a string (if it is not already a string), and the "+" operator will concatenate the two strings. This type of operation is considered to be a string operation, not a logical or arithmetic operation. (See Example 3 on page 206.)

Array Conversion

If converting a local variable declared as an array, convert each array element separately. If the conversion computation is within a loop, use one temporary variable of the new data type to represent the array index or create an array of the same size and of the new data type and load it with the converted values.

Examples of Data Type Conversion—The following four examples illustrate data type conversion.

Example 1—Converting analog values to digital

Let switch be a digital element. The statement

```
switch = 25.2
```

results in switch having a value of 1 (ON) because the assigned value (after the fractional part is truncated) is non-zero.

Example 2—Float truncation into integer

Let lastcar be an analog element (16-bit integer). The statement

```
lastcar = 47.1
```

results in lastcar having the value 47, not 47.1. Since lastcar is an integer, the decimal portion of the floating-point constant is truncated before the assignment.

Example 3—Appending numerics to messages

Let pressure be an analog element with the value 99. string1 is a message element. The statement

```
string1 = “RPT” + pressure
```

results in string1 having the value RPT99. pressure is converted to a string and then concatenated to the string constant RPT. The result (RPT99) is then assigned to string1.

The compiled mode of Math and Logic does not support appending numerics to messages.

Example 4—Equating a floating-point element to the contents of message data

Let message1 be a message element set to 1e308 (representing the number 10 raised to the power 308, a large floating-point constant stated in string form). Assume you set message2, defined the same way as message1, to a value of -1e-308 (representing the very small floating-point constant 10 raised to the power -308).

Let float1 be a floating-point element that receives the total of these two message elements. The statement

```
float1 = message1 + message2
```

which should add the two values, instead results in float1 receiving an undefined value represented in the system as 1.#INF ("is not float") or something similar, leading to an unpredictable result. This happens because the system performs string concatenation (the "+" operator acts as concatenation operator in regard to string operands), which yields 1e3081e-308. The system stops converting at the second occurrence of e (discarding the -308 portion) and attempts to place into the variable float1 the out-of-range value (10 raised to the power of 3081), which is too large to fit into the floating-point constant, and which is not the desired value.

Convert each of these values before adding them to prevent this type of error and avoid unpredictable system behavior. Create two conversion variables, float1 and float2, and replace the statement above with the following statements:

```
float1 = message1         # get first user input
float2 = message2         # get second input
float1 = float1 + float2    # sum the inputs
```

The computations can then be carried on using only float1.

Expressions

An expression is a set of arguments (operands) that resolve to exactly one value. An expression consists of some combination of the following elements:

- Operators (symbols or keywords that specify the operation to be performed)
- Variables (database element tag names and procedure variables)
- Constants (symbolic, numeric, and string constants)
- Functions

In an expression, parentheses and brackets are balanced and all operators have the correct number and types of operands. The following examples illustrate well-formed expressions (assuming the data types of each operand are valid with the operators):

```
5

x + 1

X + 3.5

temp < 0 OR temp > = 100

outrange AND (valve1 = 1 OR valve2 = 1)

100*sin(voltage1 - voltage2)

(display = “MENU”)      # logical comparison (for “IF” or
                        # “WHILE”— not an assignment!)

“This is a message to the operator!”
```

Operators

Operators are symbols or keywords that are used in expressions to specify the type of operation to be performed. Operators can be either unary or binary. Unary operators operate on only one operand at a time while binary operators operate on two operands at a time.

Math and Logic employs the following operator groups. They are listed in order of relative precedence; that is, the order in which the task performs the operations in an expression:

- Arithmetic
- Relational
- Logical
- Bitwise
- Grouping
- Change-Status
- Assignment

Arithmetic Operators

Arithmetic operators perform arithmetic operations on their operands. The following chart illustrates arithmetic operators:

Table 8-5

Operator	Type	Usage	Operands	Operation Name
+	binary	x + y	numeric	addition
+	binary	x + y	string	concatenation
-	binary	x - y	numeric	subtraction
-	unary	-x	numeric	negation
*	binary	x*y	numeric	multiplication
/	binary	x/y	numeric	division
^	binary	x^y	numeric	exponentiation
MOD	binary	x MOD y	integer	modulo (or modulus)

Place spaces before and after the keyword MOD to avoid confusion with variable names when the program parses the formula.

All arithmetic operators except modulo operate on any type of numeric operands, including floating-point. MOD functions with only integers (in the case of tag names, this means any combination of analog or long analog data types).

Math and Logic defines modulo as follows:

```
x MOD y
```

(This operation returns the remainder after dividing x by y.)

The following examples illustrate arithmetic operations:

Table 8-6

Operation	Results
17/5 = 3	Returns quotient of 3; remainder is lost
17 MOD 5 = 2	Returns remainder of 2; quotient is ignored
17.0/5 = 3.4	Result is converted to floating-point; returns quotient and remainder

Relational Operators

Relational (or comparison) operators compare one numeric operand with another and generate a result that describes the outcome of the comparison.

The result of a given comparison is 1 (TRUE) or 0 (FALSE). Math and Logic resolves all operands to numeric form.

The following chart illustrates relational operators used in comparisons:

Table 8-7

Keyword	Type	Usage	Operation Name	Operation Definition
=	binary	x = y	equal to	If x = y, result is 1. If x != y, result is 0.
!= or <>	binary	x != y	not equal to	If x = y, result is 0. If x != y, result is 1.
<	binary	x < y	less than	If x < y, result is 1. If x >= y, result is 0.
>	binary	x . y	greater than	If x > y, result is 1. If x<= y, result is 0.
<=	binary	x <= y	less than or equal to	If x <= y, result is 1. If x > y, result is 0.
>=	binary	x >= y	greater than or equal to	If x >= y, result is 1. If x < y, result is 1.

Given the short analog variable x = 3, the results of various relational operations done using **x** as an operand are shown in the following chart:

Table 8-8

Operation	Return Value
x < 10	1
x < 3	0
x < 2	0
x > 12	0
x > 2	1
x > 3	0
x != 4	1
x != 3	0
x = 4	0
x = 3	1
x <= 3	1
x <= 4	1
x <= 2	0
x >= 2	1
x >= 3	1
x >= 1	1

Logical Operators

Logical operators test operands for TRUE (non-zero) or FALSE (zero) values and return a result of 1 (TRUE) or 0 (FALSE). Math and Logic resolves all operands to numeric form.

The following chart illustrates logical operators:

Table 8-9

Operator	Type	Usage	Operation Name	Operation Definition
NOT	unary	NOT x	logical NOT (negation)	If x is zero, result is 1. If x is non-zero, result is 0.
AND	binary	x AND y	logical AND (conjunction)	If x != 0 and y != 0, result is 1. If x or y (or both) are 0, result is 0.
OR	binary	x OR y	logical OR (disjunction)	If x or y (or both) are != 0, result is 1. If x is zero and y is zero, result is 0.

Place spaces before and after the keywords AND, NOT, and OR to avoid confusion with variable names when the program parses the formula.

The following examples illustrate logical operations:

Table 8-10

Operation	Return Value
NOT 3	0
NOT 0	1
NOT - 1	0
0 AND 1	0
0 AND 0	0
1 AND 2	1

Table 8-10 (Continued)

Operation	Return Value
0 OR 2	1
0 OR 0	0
2 OR 3	1

Bitwise Operators

Bitwise operators compare and manipulate the individual bits of their operands. Math and Logic resolves all operands to integers.

The following chart illustrates bitwise operators:

Table 8-11

Operator	Type	Usage	Operands	Operation Name
!	unary	!x	integer	bitwise one's complement
&	binary	x & y	integer	bitwise AND
|	binary	x | y	integer	bitwise OR (inclusive OR)
~	binary	x~y	integer	bitwise XOR (exclusive OR)

Math and Logic defines bitwise operations as demonstrated in the following examples:

Table 8-12

<table>
<tr><th>Operation</th><th>Bit Value</th><th>Return Value</th></tr>
<tr><td>9 & 10</td><td>9 = 1001
10 = 1010
1000</td><td>8</td></tr>
<tr><td>9 | 10</td><td>9 = 1001
10 = 1010
1011</td><td>11</td></tr>
<tr><td>9 ~ 10</td><td>9 = 1001
10 = 1010
0011</td><td>3</td></tr>
<tr><td>9 ~ - 10</td><td>9 = 0000000000001001
-10 = 1111111111110110
1111111111111111</td><td>-1</td></tr>
<tr><td>! 9</td><td>9 = 0000000000001001
bitwise flip produces
1111111111110110
!9 = 1111111111110110</td><td>-10</td></tr>
</table>

Grouping operators

The following operators provide grouping information about an operation:

- **Parentheses**—Use these to group sub-expressions. Their main purpose is to override the precedence of operations by forcing the evaluation of other operations first. Also, use parentheses to enclose arguments being passed to a function or procedure.
- **Brackets**—Use these to enclose array indices. For double- or triple-indexed arrays, use multiple pairs of brackets.

- **Commas**—Use these to separate the arguments (if more than one) being passed to a function. Also, use commas between types in procedure declarations and between type-argument name pairs in procedure definition header statements (proc statements). Refer to the following chart for additional information.

The following chart illustrates special grouping operators:

Table 8-13

Operator	Type	Usage	Operands	Operation Name
(	N/A	N/A	any type	left (open) parenthesis
)	N/A	N/A	any type	right (close) parenthesis
[	N/A	N/A	any type	left (open) bracket
]	N/A	N/A	any type	right (close) bracket
,	N/A	N/A	any type	comma (between arguments)

Change-status Operators

The change-status operator checks whether the value of a element has changed since Math and Logic's last read operation (returning TRUE if the element's change-status bit has been set for any reason, including a forced-write operation). Use of the change-status operator itself resets the element's change-status bit with respect to Math and Logic.

The chart below shows the characteristics of change-status operators:

Table 8-14

Operator	Type	Usage	Operands	Operation Name
? changed	unary	(? x) (changed x)	tag name	change-status

When checking change status, do not enclose the database element name (operand) in parentheses. The construct "?(x)" is misinterpreted by Math and Logic in this context and will not produce the desired result. Always use the construct "? x" or "(changed x)."

A change-status operator is defined as follows:

Table 8-15

Operator	Definition
? x changed x	The operation returns TRUE (1) if the value of x has changed since it was last read or change-read by Math and Logic and FALSE (O) if it has not.

The following example illustrates two change-status operations:

Table 8-16

Operation	Results
y = y + ?x	Increments the value of y by 1 whenever the value of x changes.

If changed tag_name then
call proc proc_ name
Endif
	Initiates the procedure proc_name whenever the value of the element tag_name changes.

Do not perform change-status operations on elements being used as procedure triggers (trigger elements). This may prevent the corresponding procedure(s) from being triggered at the proper time. This is because checking the change status of the element resets the change bit for that element.

Assignment Operators

Assignment operators assign a value to a variable. Refer to the discussion of assignment statements in “Assignment Statements” on page 221.

Operator Precedence

Most high-level languages use relative operator precedence and associativity to determine the order in which procedures perform operations.

If one operator has higher precedence than another, the procedure executes it before the other. If two operators have the same precedence, the procedure evaluates them according to their associativity (which is either “left to right” or “right to left” and is always the same for such operators). Because parentheses are operators with very high precedence, they can be used to alter the evaluation order of other operators in an expression.

The Math and Logic operators are divided into ten categories in the following chart of operator precedence. The Change-status category has the highest precedence, the Grouping category takes second precedence, and so on to the Assignment category which has the lowest precedence. The operators within each category have equal precedence.

The Unary (third category) operators associate from right to left; all other operators associate from left to right.

Table 8-17

Precedence (1 is highest)	Category	Operator	Description
1	Change-status	?	Checks change-status of database elements
2	Grouping	( )	Grouping or function call
		[ ]	Array subscript
3	Unary	-	Unary minus
		NOT	Bitwise !'s complement
		!	Logical negation
4	Binary	&	Bitwise AND
		|	Bitwise OR
		~	Bitwise XOR

Table 8-17 (Continued)

Precedence (1 is highest)	Category	Operator	Description
5	Multiplicative	^	Exponentiation
		*	Multiplication
		/	Division
		MOD	Modulus (remainder)
6	Additive	+	Binary plus (addition)
		-	Binary minus (subtraction)
7	Relational	<	Less than
		<=	Less than or equal to
		>	Greater than
		>=	Greater than or equal to
8	Equality	=	Equal to
		!=	Not equal to
9	Logical	AND	Logical AND
		OR	Logical OR
10	Assignment	=	Variable or database element assignment
		==	Forced write (database element only)

The following examples illustrate operator precedence:

Table 8-18

Example Statement	Explanation of Operator Precedence
x , 5*y + 10 AND NOT zflag	According to precedence rules, the order of evaluation is NOT, then *, then +, then <, then AND. The program evaluates the expression as if it contained the following parentheses: (x < ((5*y) + 10)) AND (NOT zflag) To perform the addition before the multiplication, add parentheses to alter precedence, as follows: x < 5*(Y + 10) AND NOT zflag
x * y/z	Because * and / have the same precedence and they associate left to right, the program performs * before?. The program evaluates the expression as if it contained the following parentheses: (x * y)/z
x = NOT NOT y	The program evaluates the expression as if it contained the following parentheses: x = (NOT (NOT y)) This expression assigns the value 1 to x if y is nonzero. Otherwise, the expression assigns 0 to x and is equivalent to x = y ! = 0.
x = NOT ?y	The program evaluates the expression as if it contained the following parentheses: x = (NOT (?Y))
x = NOT y = z	The program evaluates the expression as if it contained the following parentheses: x = ((NOT y) = z) This expression is different from x = NOT (y=z). The latter is equivalent to x = y ! = z.
a = 1 AND b ! = 2 OR c = 3 AND d ! = 4	The program evaluates the expression as if it contained the following parentheses: ((a + 1) AND (b ! = 2)) OR ((c = 3) AND (d !=4))

Table 8-18 (Continued)

Example Statement	Explanation of Operator Precedence
x = a = b < c	The program evaluates the expression as if it contained the following parentheses: x = (a = (b < c)) This expression assigns x the flue 1 if a has the same truth value (1 or 0) as the comparison b < c. Otherwise, the expression assigns 0 to x.
x & 1 | y & 2 | z & 4	The program evaluates the expression as if it contained the following parentheses: ((x & 1) | (y & 2) | (Z & 4) If this case, it does not really matter which | the program executes first, the program executes first; the program evaluates the expression from left to right.
f(2*x + 3, 4*y + 5) - g(x, y) /2	The program evaluates the expression as if it contained the following parentheses: f (((2*x) = 3), ((4*y) = 5)) - (g(x,y)/2)

Statements

A statement is an instruction that describes mathematical and/or logical operations to be performed in a specified order. A diagrammed statement, with each of its components labeled, is illustrated below:

Statements can be one of three types:

- Assignment Statements
- Control statements
- Procedure calls

Assignment Statements

Assignment statements assign values to Math and Logic procedure variables or database elements and can have either of the following forms:

```
x = expr
```

Only writes if value of x is to be changed; valid for procedure variables and database elements.

or

```
x == expr
```

Forced write, regardless of variable's present value. Turns on change-status flags. Valid only for database elements.

where = and == are the assignment operators. Refer to “Operators” on page 208 for more information.

The assignment statement is written (whether in a formula or within a procedure) with the variable to be changed on the left-hand side of the assignment operator and the term or expression whose value should be taken (leaving it unchanged) on the right-hand side. Math and Logic computes the expression expr and assigns the result to the procedure variable or element 5 x. Refer to “Expressions” on page 207 for more information.

A significant difference exists between the two assignment operators. Refer to the examples below using database elements fptemp and itemp:

```
fptemp = itemp
```

Will not change the value of fptemp unless it is different from the value in itemp (although it will still place the integer value into a floating-point storage format).

This form is used to assign values to local and global variables as well as database elements.

```
fptemp == itemp
```

Forces the value of itemp to be stored in the variable fptemp whether or not fptemp already contains that value and sets all the change-status flags associated with fptemp.

This form is used only to assign values to database elements.

Syntax: To obtain the most efficient FactoryLink task performance, use the simplest assignment statement necessary. The following chart summarizes assignment statement syntax:

Table 8-19

Assignment Operator	Data Types of Operands	Operation Result
gvar1 = 1var2	any	Normal local/global variable assignment.
tag1 = var1	any	Assignment is made via database write call.
tag1 == var 1	database	Assignment is made via database forced-write elements only call.

End an assignment statement with an end-of-line character (¶) or a semi-colon (;).

To set the change-status bit for database element x without altering its value, use the forced-assignment operator == to equate the element to itself, as shown in the examples below:

Table 8-20

Example	Explanation
`a[3] = (a[0]+a[1]+a[2]+a[3])/4` `rtdb2 == rtdb2`	Local array assignment. Forced-write assignment, leaving the value of rtdb2 unchanged.
`x = 47.1` `x = x+1`	x is a local FLOAT.
`rtdb1 == x`	Forced-write assignment of element RTDB1.
`rtdb2 == rtdb2`	Forced-write assignment, leaving the value of rtdb2 unchanged.

Control Statements

Control statements, sometimes called conditional statements, include instructions about the circumstances under which a block of procedure code (a sequence of consecutive statements) is to be executed. End a control statement line with an end-of-line character (¶) only. Never end a control statement with a semicolon.

There are two types of control statements:

- IF...ENDIF
- WHILE...WEND (ENDWHILE)

IF...ENDIF—An IF...ENDIF statement specifies an action is to be executed only if a specified condition is true.

Syntax—The IF...ENDIF control statement has the following syntax:

```
IF expr THEN   # Block to be executed if expr is true.
[ELSE]         # Optional block to be executed if expr
               # is false.
ENDIF
```

If the test expression of the statement is true, the THEN block is executed. If the test expression is not true and an ELSE clause exists, the ELSE block is executed. The ELSE block is optional.

The IF...THEN block is not optional and the THEN verb must immediately follow the test expression on the same line as IF. Each IF statement must be ended with an ENDIF statement on a line by itself.

The following examples illustrate the use of IF…ENDIF control statements:

```
# Example 1:

IF x = 1 THEN
   a = a + 1;
   b = 20;
ELSE
   a = a - 1;
   b = 0;
ENDIF
```

```
# Example 2:

IF NOT initflag THEN
   IF (alrm gt 6) THEN
         initflag = 1;
         alrm = alrm + 1;
         CALL initproc;        # call another proc
   ENDIF
ELSE
   b = 20;
   tag2 == a - 1;
   procadd;                    # call another proc
ENDIF
```

```
# Example 3:
# take determinant of 2x2 array
det = a[0][0]*a[1][1]t-ta[0][1]*a[1][0]
# if nonzero, then invert 2x2 array a
# place resulting array in 2x2 array b
IF (det != 0) THEN
   b[0][0] == a[1][1]/det
   b[0][1] == -a[0][1]/det
   b[1][0] == -a[1][0]/det
   b[1][1] == a[0][0]/det
ELSE
   PRINT “Cannot invert this matrix!\n”
ENDIF
```

WHILE...WEND—A WHILE...WEND statement specifies a block of code is to be executed repeatedly until the test expression becomes false.

Syntax—The WHILE...WEND control statement has the following syntax:

```
WHILE test_expr      # Block to be executed while
                       test_expr remains true.
 .
 .
 .
WEND
```

If the expression test_expr is initially false, the block is never executed. If the expression never becomes false, the loop never terminates until the operator or another run-time process forces the procedure to stop running. Ensure the value of test_expr can become false at some point in the loop's execution to prevent the program from hanging.

The keyword ENDWHILE can be substituted for WEND.

The following examples illustrate the use of WHILE...WEND control statements:

```
# Example 1:

n = 0
WHILE n < 10
   a[n] = -1
   n = n + 1
WEND
```

```
# Example 2:

fib[0] = x
fib[1] = y
n = 2
WHILE n < 100 AND fib[n-1] < 10000
   fib[n] = fib[n-2] + fib[n-1]
   n = n + 1
WEND
```

Indent conditionally executed blocks for readability. This does not affect program execution.

Procedure Calls

Procedure calls are statements that cause specified procedures to execute. Procedure calls are used to reference custom-written procedures or library functions which are built into the FactoryLink system.

Syntax—Procedure calls have the following syntax:

```
[CALL] proc_name[;]

or

[CALL] proc_name(arg1{,arg2,arg3,...})[;]
```

The keyword CALL and the ending semicolon, both shown in brackets, are optional. When additional arguments exist, the items shown in braces are present.

Math and Logic copies the values used as arguments so the procedure modifies the copies, not the original values of the variables or database elements. Refer to “Arguments” on page 233 in Chapter 9, “Math and Logic Procedures and Functions,” for more information.

Block Nestability

Blocks delimited with control statements can be nested, provided each IF or WHILE statement contains an appropriate matching ENDIF or WEND statement. Blocks cannot overlap and must be matched pairs entirely within any other blocks to which they are internal. Improperly nested logic causes unpredictable results.

The following example illustrates proper procedure nesting:

```
IF x = y THEN
   n = 0
   WHILE n < 10
      a[n] = 0
      n = n + 1
   WEND
ELSE
   IF x > y THEN
      a[x-y] = 1
   ELSE
      a[y-x] = -1
      IF alert THEN
         PRINT “FOUND IT \n”
      ENDIF
   ENDIF
ENDIF
```

Excessive nesting of blocks or procedure calls can cause the operating system to halt the procedure and return a Stack overflow error. If this error occurs, either restructure the procedures to reduce the number of nesting levels or increase the stack size for Math and Logic. Contact Customer Support for information about increasing the stack size.

Directives

Directives are symbols used in statements and determine the type of statement performed. Directives must not be used in expressions. Math and Logic recognizes the following directives:

Table 8-21

Directive	Usage***	Meaning
=	x = expr	Assign expr to x (via database write or locally)
==	x == expr	Assign expr to x via a forced database write
if	if expr	Test portion of if statement
then	then block	(required) If test is TRUE, begin “then” block
else	else block	(optional) If test is not TRUE, begin “else” block
endif	endif	End of “if- then” or “if-then-else” block
while	while expr	While expr is TRUE, do “while” block
wend	wend	End of “while” block
begin (or “{“)	begin	Begin program
end (or *}*)	end	End program
call	call proc01	Execute a procedure and return (optional keywd)
proc	proc block	Define a procedure
system	x = system(* *)*	Execute a system call and return
declare	declare short x	Define a variable or declare a procedure
print	print “starting”	Print a line of text
lock	lock	Lock the database

Table 8-21 (Continued)

Directive	Usage***	Meaning
unlock	unlock	Unlock the database

*** Terms used in this table are defined as follows:

- **x** is a variable capable of being assigned a value. It may be a database variable (tag name), a Math and Logic variable, or a constant, but it may not be a function.
- **expr** stands for an arbitrary expression.
- **block** refers to any sequence of consecutive statements.

* Enclose a system call appropriate to the operating system within the double quotation marks. Virtually any system call, such as the "dir" command, is valid.

The SYSTEM directive requires operating system-specific arguments.

Chapter 9 . . . .

Math and Logic Procedures and Functions

Program Files

A program file is a text file containing the text of one or more Math and Logic procedures and has the extension .PRG. A program file is composed of procedures and declarations. Program files can contain multiple procedures; however, a program file must contain one procedure, called the main procedure, that fits two criteria:

- The main procedure has the same name as the name of the program file, minus the extension. For example, the program file MYPROC.PRG must contain a main procedure with the name MYPROC, myproc, MyProc, or some variation. Program file names are not case-sensitive.
- The procedure name entered in the Math and Logic Triggers table must be exactly the same as the name entered in the program file, including upper and lowercase characters.

Procedure names, element names, variables, and constants are all case-sensitive in Math and Logic and must be unique. However, to avoid confusion and a possible error, do not give any two procedures, element names, variables, or constants the same name, even if the case is different. Remember in UNIX, names must be lower case.

Be careful not to confuse the name of a procedure with the name of the program file in which the procedure is contained. While procedure names are case-sensitive, the name of the program file in which the procedures are contained is not case-sensitive.

At run time, if a program file does not contain a procedure that fits these criteria, no procedures in that file are triggered, and the error message “Proc (procedure name) does not exist” is displayed on the Run-Time Manager screen and in the log file.

Procedures

A procedure is a sequential arrangement of statements that manipulate data items in a repeatable fashion, always behaving the same way under the same circumstances and providing a well-defined and logical flow of control through the procedure.

Define procedures using the following general form (with no arguments):

`PROC name`	Procedure definition statement
`BEGIN` `.` `.` `.` `END`	Body of procedure, declarations, and statements

Each procedure definition statement or “proc” statement starts with the word PROC, followed by the unique name of the procedure, followed by any arguments (parameters) the procedure requires. (Any procedure, except the main procedure for the file, can have arguments.) Place the keyword BEGIN on the next line.

For example:

```
PROC name (type name1 [,type name2])
BEGIN
  .
  .
END
```

where

type	is SHORT, LONG, FLOAT, or STRING.
name1	is the name of a variable or constant or a database element tag name.
name2	is the name of a variable or constant or a database element tag name other than name1.

Math and Logic does not provide return codes for developer-defined procedures. Therefore, the task cannot set a variable’s value to the return code from a procedure call.

Do not confuse procedure definitions with procedure declarations which are forward references to procedures defined later in the same file or in a different file.

Arguments

Arguments—Arguments are values passed to a procedure for it to use in its computations; arguments are input-only parameters.

Declare arguments by placing their types and names in the procedure definition statement, as shown in the example above. Local and global variable names and tag names can be used. The data type of the argument is the same as that of the original variable or database element (SHORT, LONG, FLOAT, STRING).

Math and Logic copies the values used as arguments so the procedure modifies the copies, not the original values of the variables or elements. For example, if the tag name of a database element is used as an argument, the task copies the value of that element and sends it to the procedure as the argument. The original value of the database element is not affected. Values modified as arguments cannot be passed back to the calling procedure.

An array cannot be used as an argument to a procedure, but an array element can.

```
PROC pgm1(short non_tagnm  but  CALL pgm1(tag1)
```

In this example, the value of the digital element tag1 is copied into the procedure variable non_tagnm and converted to a short data type. Inside the procedure, operations on non_tagnm do not affect the value of tag1. However, because FactoryLink real-time elements are global, at the end of the procedure, tag1 can be assigned the value of non_tagnm.

The declaration section of a procedure definition is optional. Any of the declarations can be made in this section. Remember the two previously stated rules:

- Any variables declared within the procedure are by definition local variables and cannot be referenced outside of the procedure.
- Declarations must come before any statements.

Calling Sequence—For Math and Logic to invoke a procedure, you must specify a procedure call using one of the following interchangeable forms:

```
{CALL} proc_name[(type1 arg1 [, type2 arg2...])]  or
{CALL} proc_name(type1 arg1 [, type2 arg2...])
```

where the keyword CALL is optional.

RUNNING PROGRAMS AS INTERPRETED PROGRAMS

To run as interpreted those programs that have Interpreted entered in the Mode field of the Math and Logic Triggers Information panel, start the application by typing the FLRUN command at the system prompt.

Math and Logic begins executing interpreted programs by loading them into memory. After loading and validating the programs, Math and Logic waits for changes to the trigger elements in the real-time database associated with the procedures in the program. When a trigger element is set to 1 (ON), the task executes the program associated with that trigger.

Each time an interpreted program is executed, Math and Logic first reads, or interprets, the instructions within the program to determine the actions to perform, then it executes those actions.

Technical Notes

Calling Procedures and Functions

Two types of routines can be called from within an expression:

- Developer-defined local procedures
- Library functions

Local Procedures

Calls to local procedures, with or without arguments, are normally made using one of the forms in the chart below:

Table 9-1

Syntax	Purpose
f( ) or f	To pass no arguments
f(arg1)	To pass arg1
f(arg1, arg2)	To pass arg1 and arg2

Procedure names can be up to 16 characters, must conform to the naming rules for variables, and can be followed by a set of parentheses containing the function's input parameters (arguments), if any are required.

To be compatible with all operating systems, the main procedure for each .PRG file should have a name of up to 8 characters.

Library Functions

A number of specialized procedures, known as functions, are predefined by, or built into, Math and Logic. Functions built into Math and Logic are known as library functions. Expressions can include calls to library functions. The library functions supplied with Math and Logic are grouped into five categories:

- Mathematical
- Directory/Path Control
- String Manipulation
- Programming Routines
- Miscellaneous Routines

The functions within each category are described in the following sections. Included in each function's description is a sample format of the function and an example of its use.

Functions can vary among different operating systems. Refer to your operating system's documentation for information about specific functions for a particular operating system.

Table 9-2 Mathematical Functions

Function:	Sample Format:	Description:
abs Example: Therefore:	**x** = abs(y) x = abs(-5) x = 5	Returns absolute value
cos Example: Therefore:	**x** = cos(y) x = cos(.4) x = 0.921061	Returns the cosine of *y*. Specify *y* in radians.
exp Example: Therefore:	**x** = exp(y) x = exp(4) x = 54.59815	Returns *ey*
log Example: Therefore:	**x** = log(y) x = log(100) x = 2	Returns the log base 10 of *y*

Table 9-2 Mathematical Functions (Continued)

Function:	Sample Format:	Description:
loge Example: Therefore:	x = loge(y) x = loge(1) x = 0	Returns the natural log of *y*
pow Example: Therefore:	x = y pow (z) = 2 pow (3) x = 8	Returns *y* to the *z*th power
rnd Example: One possible result:	x = rnd x = rnd x = 32750	Returns a pseudo-random positive integer within the range **0** to **32767**
Note: "32765" represents only one of many possible results from this call made to the pseudo-randomizer. This function cannot be "seeded," as can a more sophisticated randomizing function, and therefore it tends to generate the same sequence of integers each time it is run. No routine can choose truly random numbers. Probability functions are a main component of these library routines, which are heavily dependent on the handling of the routine by the particular operating system. Pure random numbers are normally not needed, but we recommend you investigate writing a custom randomizer function, seeded differently each time the function is called. It is beyond the scope of this document to discuss the uses and characteristics of randomizing functions, but many texts provide a point-of-reference. This function, however, is serviceable for the developer who wants to specify a different number for a sort or pointer each time the routine is entered, such as, start at a different belt each time red cars are sought on the conveyors. If randomness is necessary, contact Customer Support.		
sin Example: Therefore:	x = sin(y) x = sin(1.5) x = 0.9974951	Returns the sine of *y*. Specify *y* in radians.
sqr Example: Therefore:	x = sqr(y) x= sqr(144) x = 12	Returns the square root of *y*

Table 9-2 Mathematical Functions (Continued)

Function:	Sample Format:	Description:
tan Example: Therefore:	x = tan(y) x = tan (.785) x = 1	Returns the tangent of *y*. *y* is specified in radians

Directory/Path Control Functions

Directory and path control functions are unique to each operating system.

Table 9-3 String Manipulation Functions

Function:	Sample Format:	Description:
alltrim Example: Therefore:	string = alltrim(string) msgvar = alltrim("SMITH") msgvar = "SMITH"	Returns *string* with leading and trailing blanks trimmed
asc Example: Therefore:	x = asc(string) x = asc ("TEN") x = 84 (84 is the ASCII code for T.)	Returns the ASCII value of the first character in *string*
chr Example: Therefore:	string = chr(var) msgvar = chr(66) msgvar = "B" (66 is the ASCII code for B.)	Returns equivalent character of an ASCII code
instr Example: Therefore:	x = instr(str1, str2) x = instr("ABCDE","B") x = 2	Returns the offset into *str1* of the occurrence of *str2*
len Example: Therefore:	x = len (string) x = len("MIAMI, FLORIDA") x = 13	Returns the length of *string*, not including the terminator

Table 9-3 String Manipulation Functions (Continued)

Function:	Sample Format:	Description:
lower Example: Therefore:	string = lower (string) msgvar = lower (“NOT”) msgvar = “not”	Returns *string* converted to lower case
ltrim Example: Therefore:	string = ltrim (string) msgvar = ltrim (“SMITH”) msgvar = “SMITH”	Returns *string* with leading blanks trimmed
substr Example: Therefore:	string=substr (string, offset, len) msgvar = substr(“ABCDE”, 3, 2) msgvar = “CD”	Returns a string of *len* length or less beginning with the offset character from the beginning of *string*. The offset to the first character in *string* is **1**.
trim Example: Therefore:	string = trim(string) msgvar = trim(“SMITH”) msgvar = “SMITH”	Returns *string* with trailing blanks trimmed
upper Example: Therefore:	string = upper(string) msgvar = upper(“not”) msgvar = “NOT”	Returns the input, *string*, converted to upper case

For Windows NT and Windows 95

Table 9-4 Directory/Path Control Functions

Function:	Sample Format:	Description:
getdir	string = getdir(drive)	Returns the current path of specified drive. drive = 0 current drive drive = 1 a: drive = 2 b: and so on.
Example: Therefore:	string = getdir(1) string = a:	
getdrive	drive = getdrive	Returns current disk number. drive = 1 a: drive = 2 b: and so on.
Example: Therefore:	drive = getdrive drive = 2 (if current drive is drive **b**)	
setdir	status = setdir(drive, path)	Returns zero for success. Sets new current drive/directory. drive = 0 current drive drive = 1 a: drive = 2 b: and so on.
Example: Therefore:	status = setdir(1,"a:\test") status = 0 (if current drive/directory successfully set to **a:\test**)	

Table 9-4 Directory/Path Control Functions (Continued)

Function:	Sample Format:	Description:
setdrive	stat = setdrive(drive)	Returns zero for success. Sets new current drive. drive = 1 a: drive = 2 b: and so on.
Example:	stat = setdrive(1)	
Therefore:	stat = 0 (if current drive successfully set to drive **a**)	

For OS/2

Table 9-5 Directory/Path Control Functions

Function:	Sample Format:	Description:
getdir	string = getdir(drive)	Returns the current path of specified drive. drive = 0 current drive drive = 1 a: drive = 2 b: and so on.
Example: Therefore:	string = getdir(1) string = “a:\”	
getdrive	drive = getdrive	Returns current disk number. drive = 1 a: drive = 2 b: and so on.
Example: Therefore:	drive = getdrive drive = 2 (if current drive is drive **b**)	
setdir	status = setdir(drive,path)	Returns zero for success. Sets new current drive/directory. drive = 0 current drive drive = 1 a: drive = 2 b: and so on.
Example: Therefore:	status = setdir(1,”a:\test”) status = 0 (if current drive/directory successfully set to “**a:\test**”	

Table 9-5 Directory/Path Control Functions (Continued)

Function:	Sample Format:	Description:
setdrive	stat = setdrive(drive)	Returns zero for success. Sets new current drive. drive = 1 a: drive = 2 b: and so on.
Example:	stat = setdrive(1)	
Therefore:	stat = 0 (if current drive successfully set to drive **a**)	

For UNIX

Table 9-6

Function:	Sample Format:	Description:
setdir	status = setdir(*, path)	Returns zero for success. Sets new current directory.
Example:	status = setdir(*,/test)	
Therefore:	status = 0 (if current directory successfully set to /test)	

Programming Routines

The chart below lists programming routines alphabetically.

TRACE is not supported in the compiled mode of Math and Logic.

Table 9-7 Programming Routines

Syntax:	Description:
EXIT(status)	Exit the program and set the program return status.
CALL procname([p1...])	Call a procedure. The keyword CALL is not required. (Refer to “Procedure Calls” on page 226 in Chapter 8, “Math and Logic Syntax.”)
INPUT string_prompt, var1, var2...	Accept input from keyboard. The first field entered is placed in **var1**. The first comma entered begins second field, which is placed in the **var2**, and so on.
LOCK	Lock the database. No other task can access the database while it is locked. A LOCK statement delimits a block of code to be executed in critical mode; that is, without interference from other FactoryLink tasks running on the system. For each LOCK statement, there MUST be an UNLOCK statement.
UNLOCK	Unlock the database, allowing other tasks to access it. Must be issued for every LOCK. *If time-consuming code is included between LOCK and UNLOCK statements, performance may be affected, because no other tasks can access the database while it remains locked.*
PRINT “Row and line:”, row1, line	Send each listed print parameter (variable) to the display, converting to ASCII, if necessary.

Table 9-7 Programming Routines (Continued)

Syntax:	Description:
TRACE expr *TRACE will not be supported in future add-on products.*	While **expr** remains true, each line assignment, and the procedure's exit point are printed as they run.

Miscellaneous Routines

Table 9-8 Miscellaneous Routines

Function:	Sample Format:	Description:
argcnt Example: Therefore:	**x** = argcnt x = argcnt x = 3 (if the number of program arguments is 3)	Returns the number of program arguments.
getarg Example:	**x** = getarg(argnbr) x = getarg(2) x = TEST (if the second argument is the directory name, which is TEST)	Returns the specified program argument.

system
Example:
Result:
	x = system
	("system command")
	x = system("copy c:\\autoexec.bat b:\\bat")
	# OS/2 system call
	x = 0 (if the copy request was successful)
		Allows system calls. The command is formatted as a string. Returns success **(0)** of failure **(1)** of operation.

The return code from the operating system is placed in the variable represented here by x to check whether the requested system command was completed without errors. If there were no errors, the function returns 0; otherwise, at least one error on the request occurred.

To transmit one backslash (\) character, type two backslashes. Doubling the character causes the system to recognize it as a literal character.

System command represents a call made to the operating system. This might be a simple directive such as DIR C:, or it might be complex, such as a request to execute a batch file to request values or inputs from the user (“@GETID”) or to request another operating system shell (“DOSSHELL”). Arguments to the SYSTEM function are operating system-dependent.

For Windows NT and Windows 95

Under Microsoft Windows, the SYSTEM function is asynchronous; that is, the SYSTEM function returns immediately. The operating system command runs in parallel to Math and Logic. If the command is started, the return value of the SYSTEM function is 0 (zero); otherwise, the return value is -1.

Note that using this feature makes procedures non-portable without manual conversion of the system calls to those appropriate in the target system.

For OS\2

The SYSTEM function sends the specified operating system command to the operating system and begins a subprocess that passes the request to a DCL Command Line Interpreter (CLI). The Run-Time Manager screen for the particular domain in which Math and Logic is running displays the output the CLI produces while processing the request. Enclose the desired system command in double quotes.

To obtain directory listings of files in the current (active) drive/path, use:

```
SYSTEM(“dir”)
```

OS/2 returns a status code, with **1** indicating success and any non-zero value indicating failure. Virtually any system command valid from the normal OS/2 prompt is valid when sent through the SYSTEM function.

Using this feature makes procedures non-portable without manual conversion of the system calls to those appropriate in the target system.

For UNIX

The SYSTEM function sends the specified operating system command to the operating system and spawns a subprocess that passes the request to a DCL Command Line Interpreter (CLI). The Run-Time Manager screen for the particular domain in which Math and Logic is running displays the output the

CLI produces while processing the request. Enclose the desired system command in double quotes.

To obtain directory listings of files in the current (active) drive/path, use:

```
SYSTEM(“ls”)
```

UNIX returns a status code with 1 indicating status and any non-zero value indicating failure. Virtually any system command valid from the normal UNIX prompt is valid when sent through the SYSTEM function.

Note that using this feature makes procedures non-portable without manual conversion of the system calls to those appropriate in the target system.

Calling Functions that Operate on Tag IDs (CML Only)

Math and Logic provides a function that looks up tag names and retrieves their tag IDs so developers can call and use functions that operate on tag IDs and not tag names. This function is:

```
int fl_tagname_to_id(TAG*tp, int num, char*tagname,...);
```

where

TAG*tp	is a pointer to a developer-supplied tag array to be filled in with tag IDs
int num	is the number of tag names to look up.
char*	is one or more character pointers to valid tag names.

This function returns a code indicating either GOOD or ERROR. It is designed for developers who integrate C source code into their Math and Logic programs and is available through the CML run-time library.

By using fl_tagname_to_id() inside CML C code blocks, developers can look up one or more tag names and fill in a developer-supplied tag array with the tag ID for each tag name. Developers can then use these Tag IDs with the FactoryLink PAK functions, and any other function that operates on the tag ID instead of the tag name, just as the Math and Logic grammar does.

fl_tagname_to_id() is a variable argument function like print. The developer can retrieve as many valid tag IDs as tag array has room for.

The following example shows how to use fl_tagname_to_id():

```
.
.
cbegin
void   myfunc()
{
TAG list[2]
   fl_tagname_to_id(list, 2, “TIME”, “DATE”);
.
.
}
cend
```

In this example, the function retrieves the tag IDs for the two real-time database elements TIME and DATE and places their IDs into the tag array named list.

Chapter 10 . . . .

Compiled Math and Logic

The FactoryLink Math and Logic task executes user written procedures, i.e., scripts that coordinate objectives and other FactoryLink tasks. These procedures can be written so, at run time, they are triggered by responses to changes in the RTDB or they can be executed directly from within other Math and Logic procedures.

Math and Logic is a task that includes integrating several components. These work in the following relationship.

Pre-FactoryLink Run Mode Setup

1. System Configuration Panel Setup
2. Configuration of FactoryLink Table
    A. Variables Table
    B. Triggers Tab
    C. Procedures [user constructed logic]

IF in Interpreted Mode:

application is ready to run and FactoryLink application starts.

IF in Compiled Mode:

processing procedures for running programs must be created:

1. PARSECML [producing C code]
2. CCCML [compiling and linking generated code]
3. Executables for domains ready for running [cuser.exe and cshared.exe],

then FactoryLink application starts.

Procedures Operating at Run Time

FactoryLink tasks are running

Triggers are turning on and off

Procedure logic is running in either IML or CML or Both

Orderly FactoryLink Shutdown

SYSTEM CONFIGURATION PANEL SETUP UNDER IML/CML

When you use IML or CML, you must always determine the correct task setting in the System Configuration Panel. The default setting for the Math and Logic task is to run in IML mode. To run Math and Logic in Compiled mode, the task name must be changed to CML and the executable file field must be set to "bin/cml". You may choose to run both IML and CML tasks in the same domain. If this is the case, you must add the second task. The best way to do this is to copy the last line in the system configuration panel and paste it in below the line just copied. You can then change the flags, task name, description, and increment the index of all array elements start_trigger through the display_description. Make sure you change the executable file to "bin/iml" or "bin/cml", whichever is applicable.

10
Math and Logic

MAKEFILES

A makefile is a file containing all the information needed by the `CCCML` utility to compile the `.C` files produced by `PARSECML` and create an executable for the current domain. The name of the makefile used by `CCCML` is `CML.MAK`, and is unique for each operating system.

The `CML.MAK` file, located in the `/FLINK/CML` directory, contains the following information to create the final executable file:

- Name of the C compiler to use for a given operating system
- Command-line switches to be used when compiling
- Name of the operating system's object linker
- Linker command-line switches
- References to the FactoryLink libraries to be linked
- References to the developer-supplied libraries to be linked

Editing CML.MAK

As an aid for advanced users, CML provides a method for editing the `CML.MAK` file. You can change the compiler and linker options, specify command-line switches, and specify which object files and libraries to link, giving you the flexibility to create a makefile unique to an application for a given domain.

CML provides two options on the Main Menu for editing `CML.MAK`:

- Math and Logic System Makefile
- Math and Logic Domain Makefile

Math and Logic System Makefile

Any changes made to this file are global; they apply to all applications on the system. To edit `CML.MAK`:

1. Choose Math and Logic System Makefile from the Main Menu to display a text editor containing the CML.MAK file from the /FLINK/CML directory.
2. Edit the file as required.
3. Save and exit the file.

Math and Logic Domain Makefile

The first time you choose Math and Logic Domain Makefile from the Main Menu, an empty text editor is displayed because a domain-specific makefile does not exist. You can create one using the master makefile `CML.MAK` in the `/FLINK/CML` directory as a model. To create a domain-specific makefile:

1. Copy `CML.MAK` from the `/FLINK/CML` directory to either:
   - `/FLAPP/USER/CML` directory for the user domain
   - `/FLAPP/SHARED/CML` directory for the shared domain
2. Open the Main Menu and ensure the current domain selected in the Configuration Manager Selection box matches the domain of the makefile you are creating.
3. Choose Math and Logic Domain Makefile from the Main Menu to display a text editor containing the domain-specific makefile CML.MAK copied in Step 1.
4. Edit the file as required.

   Any definitions in the domain-specific makefile in the application directory override the definitions in the master makefile in `/FLINK/CML` directory.
5. Save and exit the file.

THE CML PROCESS

When you have completed configuring the three tables, Variables Table, Triggers Table, and Procedures Table, you have created the processing procedures for running programs in CML. The following discusses the process involved in producing an executable file for the given domain from the .PRG files.

CML is made up of several FL utilities along with a third-party ANSI C language compiler working together at run time to generate ANSI C code from the *.prg files you created. This C code is then compiled and linked to produce an executable for each domain configured to run in CML.

This process begins when you create the *.prg files in configuration manager with the procedure editor. At run time or from running FL utilities, the *.prg files are parsed [parsecml -Nuser -V2 -CJ] which produces C code from the procedure files. The compiler is then called to produce the associated object files. This is followed by the linker called to link the objects together to generate the executable for the given domain.

This occurs in both the SHARED and the USER domains. The associated executables are

/{FLAPP}/USER/CML/CUSER.EXE	for the USER domain
/{FLAPP}/SHARED/CML/CSHARED.EXE	for the SHARED domain

GENERATION OF CML EXECUTABLES

The executables generated are

{FLAPP}/SHARED/CML/CSHARED.EXE

{FLAPP}/USER/CML/CISER.EXE

1. Validation

   The first step in the process is saving the procedure with the FactoryLink procedure editor. When you save, the grammar syntax of the procedure is checked by the math validation utility. Always make sure all procedures validate and all lines are less than 80 characters in length. Otherwise, your results will be unpredictable.

   a. The validation routine either accepts the source as it has been input or it highlights it in red. You must correct all grammar syntax before proceeding with the developing of the process of generating C code.

2. Generation of C code

   The PARSECML utility used to generate C code is

   {parsecml { [-NDOMAIN] [-V[0-5]] [-c]   discussion to follow.}

   The procedure is then parsed and the IML code is read and converted into ANSI C code. The utility that parse's the iml grammar and produces ANSI C code is PARSECML.exe. This may receive several different arguments (discussed later) when called.

   a. The IML grammar syntax that you have entered and the editor has validated is now processed by the parser.

   b. CML generates one or more files that list the triggered procedures. These files are named cmlproc*.c where * is an integer 0 through 9. The files each contain 512 declarations of triggered procedures. If the size of the application warrants, then you may have several files of the format, cmlproc0.c, cmlproc1.c, and so forth.

   c. All the global data declared in the procedure is processed and put in the file glvars.c and glvars.h. These two files are created by the CML task. The file glvars.h also holds function prototypes for user-defined functions or procedures. The file glvars.c also contains a function definition: *long fl_ftol(double).* This function is required in conversions of floating-point values to a long integer value. When type casting a floating-point to a long, a call is

made to a compiler specific function to convert the compiler's internal storage format of floating-point values to a long integer value. This function is unique to each compiler manufacturer and they may name the conversion function differently.

Inside the CML library, you need to perform floating-point to long conversions. To be able to support the MSC 6.0 and IBM C/2 compilers for FactoryLink for OS/2, we have created the function *long fl_ftol(double)* and placed it in the file glvars.c. In the CML library, we call this function only when casting floating-points to longs. This results in compiler independence.

Remember: global variables are user-defined variables that are declared outside the body of any procedure. All global data is placed in glvars.c.

d. All the FactoryLink tags used in the procedures that are also in the FactoryLink (RTDB) Real-Time DataBase are listed in the file named tags*.bin and is created by the CML task. These files are named in similar fashion as the cmlproc*.c files. Each file can contain 500 tags. When the 500 tag limit is reached, close the current tags*.bin file and start the next one, i.e., tags0.bin, tags1.bin, and so forth. These files are of binary format. You can view the contents using a hex editor (DOS debug). The tags*.bin files contain a listing of the tag segment and offset in theFactoryLink RTDB,FactoryLink type in integer format and the dimension of array if the tag is an array. CML references this information at run time by looking this information up and not having to calculate it. This reduces the CML overhead and makes for a very efficient process.

e. The pure C code that lies between the CBEGIN ...CEND keywords will not be parsed. It will be translated directly to the generated C file. The location in the file will be preserved.

f. The parsecml executable can be run from the command line. This is an excellent debug tool to assure yourself that the associated PRG files have the correct syntax.

If the FLAPP environment variable is set, you may execute parsecml with no arguments.

If you want control in executing parsecml, you can call it with the following arguments.

parsecml [[-V[1-5]] [-Nuser] [-C]]

Syntax of arguments:

- V[1-5] This specifies the verbose level built into the parsed C code that FL produces. The different levels do the following:

Usage: -V2 or -V5, etc.

Verbose Level	Action
1	prints out file names as they are parsed
2	prints out funcs/proc names as they are parsed
3	places printf()'s in each function to show entry and exit of that function
4	places printf()'s in each function to display each line as it executes. Also prints out the received values of procedures to the display when they are called.
5	Displays the lexemes of the functions as they are parsed
-NDOMAIN	This argument specifies domain FactoryLink utility:

Usage:-Nuser or -Nshared

-C This argument specifies that you want a clean rebuild of all the *.c files generated. This is the same as deleting all the file in the {FLAPP}/user/cml, or {FLAPP}/shared/cml directories. {

The use of the verbose levels -V3 and above can cause the linker error, DGROUP Exceeds 64K. This is because of the large number of strings inserted in the printf(...) statements. Please limit the use of -V3 and above to debug use only.

g. The following is the output from the command line when running:

[E:\FLNEW\USER\CML]parsecml -V2 -Nuser -C

creating tag definition file: e:\FLNEW\user\cml\tags0.bin

processing file: e:\FLNEW\user\cml\test.c

procedure: test

[E:\FLNEW\USER\CM]

The following is the output from: **parsecml -V5 -Nuser -C**

```
[E:\FLNEW\USER\CML]parsecml -V5 -Nuser -C
creating tag definition file: e:\FLNEW\user\cml\tags0.bin
processing file: e:\FLNEW\user\cml\test.c

procedure: test
(279)T_PROC         :test
(277)T_BEGIN        :00000000
(260)T_EQ           :llocvar
(290)T_INT          :00000000
(311)T_DOT          :llocvar = 0
(318)T_PRINT        :00000000
(293)T_STRING       :”You have entered the body of PROC
                    test.prg\n”
(311)T_DOT          :PRINT “You have entered the body of PROC
```

```
                 test.prg\n"
(276)T_WHILE       :00000000
(320)T_LVAR        :LLOCVAR
(290)T_INT         :00000003
(259)T_LE          :00000000
(277)T_BEGIN       :00000000
(311)T_DOT         :WHILE llocvar <=3
(318)T_PRINT       :00000000
(293)T_STRING      :"INSIDE THE WHILE LOOP\n"
(311)T_DOT         :PRINT "INSIDE THE WHILE LOOP\n"
(260)T_EQ          :llocvar
(320)T_LVAR        :llocvar
(290)T_INT        :00000001
(269)T_ADD        :00000000
(311)T_DOT        :llocvar = llocvar + 1
(278)T_END      :00000000
(311)T_DOT        :WEND
(365)T_CCODE      :printf("FactoryLink is the Best\n");
(365)T_CCODE      :for(i = INITVAL; I<=UPBOUND; i+=INCREMENT) {
(365)T_CCODE     :/*i,INITVAL, UPBOUND, INCREMENT, are defined
                and declared in test.h
(365)T_CCODE      :Body of for loop..., must be careful of
                referencing
(365)T_CCODE      :factorylink tags in CBEGIN ...CEND, block,
                must assign the tag to a local
(365)T_CCODE      :outside of block and then process the local
                and then assign value back
(365)T_CCODE     :to tag outside of the CBEGIN ... CEND bloc.
```

```
(365)T_CCODE      :*/
(365)T_CCODE      :printf("inside the for loop\n");
(365)T_CCODE      :}
(365)T_CCODE      :
(311)T_DOT        :
(278)T_END        :00000000
   ( 0)T_BADTOK   :00000000
[E:\FLNEW\USER\CML]
```

3. Description of the files generated by parsecml

   The following test.c is generated by parsecml -V3 -NUSER -C

```
/*File:------------test.c---------------*/
#include <stdio.h>
#include <stdlib.h>
#include <flib.h>
#include <math.h>
#include <string.h>
#include  <cml.h>
#include "glvars.h"

#include <test.h>
void         test( void)
{
long         llocvar;
char        strlocvar[MAXMSG];
short       slocvar
double     flocvar;
```

```
        memset( &llocvar, 0, sizeof( llocvar ) );
        memset( strlocvar, 0, sizeof( strlocvar ) );
        memset( &slocvar, 0, sizeof( slocvar ) );
        memset( &flocvar, 0, sizeof( flocvar ) );

        Procname = “test”
        printf(“\nCML: Entering procedure: test\n”);
        cirstack();

             /* PRINT “INSIDE THE WHILE LOOP\N” */
             cirstack();
          pushstr( “INSIDE THE WHILE LOOP\N”);
          doprint(pop());

          /* llocvar = llocvar + 1 */
          puchlong( llocvar);
          pushint( 1 );
          doadd();
          llocvar = poplong();
}

    /*WEND*/
printf(“FactoryLink is the best\n”);
for(i = INITVAL; i <= UPBOUND; i += INCREMENT) {
       /*I, INITVAL, UPBOUND, INCREMENT, are defined and
      declared in test.h
```

```
 Body of for loop..., must be careful of referencing
factorylink tags in CBEGIN ...CEND block, must assign the
tag to a local outside of block and then process the local
and then assign value back to tag outside of the CBEGIN
... ECEND block.
*/
printf("Inside the for loop\n")
}
printf("CML: Leaving procedure: test\n")>
}
```

4. Utility that links the associated object files to produce the executable

   Usage: **cccml [-NDOMAIN]**

5. The next process that happens to the generated ANSI C code is to be linked with the other files and necessary libraries to produce the domain executable file {FLAPP}/SHARED/CML/CSHARED.EXE or {FLAPP}USER/CML/CUSER.EXE. The linking is done by a call to the utility cccml.exe. This function is given a list of the object modules to be linked to produce the executable. The list of objects is in the file, cml.lnk.

   File: cml.lnk

```
/NOE/ST:16384/SE:512test +
syscp++
cfunk +
cbwtags +
glvars +
CMLPROC0
e:\FLNEW\user\cml\cuser.exe
cml.map
E:\FLOS2431\lib\flib.lib +
e:\FLOS2431\lib\cml.lib +
```

E:\FLOS2431\cml\cml.def

This file, cml.lnk, is the file passed to the linker. It tells the linker what files and libraries need to be linked together to produce the desired executable: cuser.exe or cshared.exe.

6. Utility **mkcml.exe**

   This utility encompasses all of the utilities that comprise the generation of C code. Usually you will call mkcml instead of separately calling all of the other steps. This utility calls ctgen to make sure the iml.ct is up to date, then it calls parsecml to parse the code, and finally it calls cccml to link the associated files and produce an executable. Remember that arguments are not case sensitive. The syntax of mlcml is as follows.

mkcml [[-V[1-5]] [-NDOMAIN] [-C]]

Syntax of arguments:

- V[1-5] This specifies the verbose level built into the parsed C code that FL produces. The different levels do the following:

Usage: -V2 or -V5, etc.

Verbose Level	Action
1	prints out file names as they are parsed
2	prints out funcs/proc names as they are parsed
3	places printf()'s in each function to show entry and exit of that function
4	places printf()'s in each function to display each line as it executes. Also prints out the received values of procedures to the display when they are called.
5	Displays the lexemes of the functions as they are parsed

-NDOMAIN This argument specifies domain FactoryLink utility:

Usage:-Nuser or -Nshared

-C This argument specifies that you want a clean rebuild of all the *.c files generated. This is the same as deleting all the file in the {FLAPP}/user/cml, or {FLAPP}/shared/cml directories. {

The following is the output of running mkcml -V2 -Nuser -C:

```
creating tag definition file: D:\CMLDOC\ZIP\FLAPP\user\cml\tags0.bin
processing file: D:\CMLDOC\ZIP\FLAPP\user\cml\test.c
      procedure: test
processing file: D:\CMLDOC\ZIP\FLAPP\user\cml\syscp.c
      procedure: syscp
processing file: D:\CMLDOC\ZIP\FLAPP\user\cml\cfunk.c
      procedure: cfunk
processing file: D:\CMLDOC\ZIP\FLAPP\user\cml\cbwtags.c
      procedure: cbwtags
test.c
syscp.c
cfunk.c
cbwtags.c
glvars.c

Building Compiled Math and Logic task for application
      D:\CMLDOC\ZIP\FLAPP
      at domain: user
Compiling: cl -DOS2 -Au -Od -Zp -G2s -nologo -c -ID:\FLOS2431\inc
test.c
Compiling: cl -DOS2 -Au -Od -Zp -G2s -nologo -c -ID:\FLOS2431\inc
syscp.c
Compiling: cl -DOS2 -Au -Od -Zp -G2s -nologo -c -ID:\FLOS2431\inc
cfunk.c
Compiling: cl -DOS2 -Au -Od -Zp -G2s -nologo -c -ID:\FLOS2431\inc
cbwtags.c
Compiling: cl -DOS2 -Au -Od -Zp -G2s -nologo -c -ID:\FLOS2431\inc
glvars
Compiling: cl -DOCCMLPROC0.C
```

```
Microsoft (R) Segmented-Executable Linker Version 5.10
Copyright (C) Microsoft Corp 1984-1990. All rights reserved.

Object Modules [.OBJ]: /NOE/ST:16384/SE:512 test +
Object Modules [.OBJ]: syscp +
Object Modules [.OBJ]: cfunk +
Object Modules [.OBJ]: cbwtags +
Object Modules [.OBJ]: glvars +
Object Modules [.OBJ]: CMLPROC0
Run File [test.exe]: D:\CMLDOC\ZIP\FLAPP\user\cml\cuser.exe
List File [NUL.MAP]: cml.map
Libraries [.LIB]: D;\FLOS2431\lib\flib.lib +
Libraries [.LIB]: D;\FLOS2431\lib\cml.lib +
Definitions File [NUL.DEF]: D:\FLOS2431\cml\cml.def;
S2 -Au -Od -Zp -G2s -nologo -c -ID:\FLOS2431\inc CMLPROC0.c
Linking: link @cml.lnk
Executing: D:\FLOS2431\bin\ctgen.exe -diml.ctg -AD:\CMLDOC\ZIP\FLAPP
-v
Switching to domain: user
Updating Compiled Math and Logic Task for Domain: user
Executing:  D:\FLOS2431\bin\parsecml.exe -AD:\CMLDOC\ZIP\FLAPP -nuser
-v2 -c
Executing:  D:\FLOS2431\bin\cccml.exe -AD:\CMLDOC\ZIP\FLAPP -nuser -v2
-c
```

The execution of flrun will call the utility mkcml for you. We recommend running mkcml before running flrun. In this way, all errors are clearly seen and the application does not start up until you are sure that all Math and Logic is syntactically correct.

Part VII

Scaling & Deadbanding

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Scaling & Deadbanding

Scaling & Deadbanding

Scaling & Deadbanding

The Scaling and Deadbanding task (SCALE.EXE) is used to convert, or scale, incoming raw data to a different value range and to indicate a dead or non-recalculating band around a scaled value.

The linear scaling feature of the task is used to convert or scale the incoming raw data to a different value range. Many values read from a programmable logic controller (PLC) are in units other than those the user wishes to display, manipulate and/or archive. Use of the scaling task eliminates the need to process data through an intermediate routing mechanism and the need to write code to perform the scaling function when the scaling is linear. The scaling task, if given ranges for the incoming and desired data values, can derive the necessary conversion factor and/or offset and perform the linear scaling calculations automatically using the formula:

$$mx + b = y$$

where **x** is the raw value, **m** is the multiplier, **b** is a constant and **y** is the result.

The Deadbanding task is used to indicate a band, or area, around a value small enough to be considered insignificant. In this case, the new value is stored and a new deadband recalculated, but the new value is not written to the program database. Since FactoryLink tasks process values upon every change, deadbanding provides a means of saving processing time and improving system efficiency. Note that the deadbanding portion of the function cannot be implemented without configuring the scaling portion of the function.

Refer to the *Application Editor Guide* for more information on how the Scaling and Deadbanding feature works in the Application Editor.

PRINCIPLES OF OPERATION

Scaling is only available in the SHARED domain. The scaling function only applies for tags with an analog, longana or float data type.

Scaling is configured using a pair of ranges: one for raw values and one for scaled values. These ranges can be specified as constants or tags. If one or more of the range tags is changed, the scaling formula is adjusted accordingly.

Note
If Scaling and Deadbanding is configured from the Application Editor, the system automatically assigns default tag names for raw and scaled values (even if entered as a constant), deadbanding and scaling lock functions. However, if Scaling and Deadbanding is configured from within the Configuration Manager, only those tags specified by the designer are created.

When a value is written to a raw value tag, its related scaled value tag is updated accordingly. When a value is written to a scaled value tag, its raw value tag is updated accordingly. The former is called a raw-to-scaled conversion. The latter is called a scaled-to-raw conversion.

Prior to changing a range tag, raw value tag or scaled value tag, the function should be disabled using the Scaling Lock Tag. When the Scaling Lock Tag has a non-zero value, changes made to the tag are not propagated to their related members. After the changes to that function have been made and the function has been re-enabled, the current raw value is scaled and written to the scaled value tag. Any changes to the ranges are applied to the scaled value as well.

Deadbanding, which applies to raw-to-scaled conversion but not to scaled-to-raw conversion, may be specified in one of two ways: as an absolute (ABS) number of Engineering Units (EUs) or as a percentage (PCT) of the scaled range. During raw-to-scaled conversion, a newly calculated scaled value that does not exceed the deadband will not be written to the database. If deadbanding is being applied to a tag associated with scaling rather than a specific alpha-numeric range, then deadbanding should be specified by a percentage of a range rather than as an absolute value. If the deadband variance for a scaled tag is specified as an absolute value, then no deadbanding is applied to the associated raw tag.

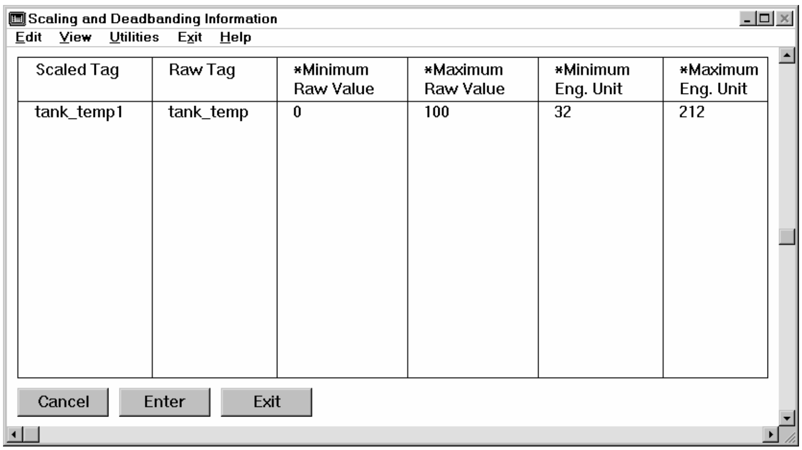
For this example, assume the temperature of the liquid in a tank is being monitored. The tank temperature probe records raw (incoming) data on a Celsius scale. The operators monitoring the temperature are more familiar with the Fahrenheit scale and wish to have the data displayed on that scale.

The temperature never falls below freezing or above the boiling point.

Defining Scaling and Deadbanding Operations

1 To open Scaling & Deadbanding, open the Configuration Manager Main Menu and ensure the current domain selected is SHARED in the Configuration Manager Domain Selection box.

2 Double-click Scaling and Deadbanding from the Configuration Manager Main Menu to open the Scaling and Deadbanding table.

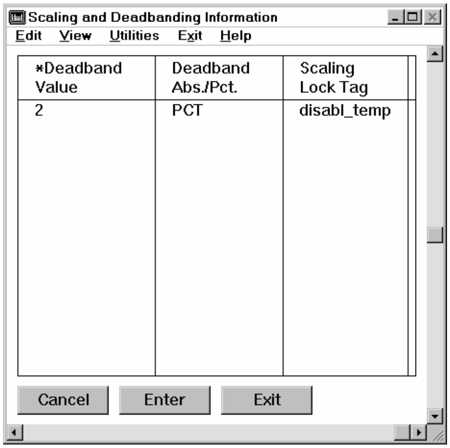


3 Enter the following information for each scaling or deadbanding operation.

Scaled Tag	Enter the name of the tag to which scaled values will be written. In this example, the tag is named tank_temp_f (for tank temperature in Fahrenheit scale)
Raw Tag	The tag for the field from which raw values are to be read. In this example, the tag is named tank_temp.
Minimum Raw Value	The lowest value for raw data. Either a constant value or a tag can be specified in this field. For this example, raw data is being read on the Celsius scale. Because the temperature will never drop below freezing, this means a minimum raw value of 0 degrees on the Celsius scale.
Maximum Raw Value	The highest value for raw data. Either a constant value or a tag can be specified in this field. For this example, raw data is being read on the Celsius scale. The temperature will never rise above boiling or a maximum raw value of 100 degrees on the Celsius scale.

Minimum Eng. Unit The lowest value for scaled data. Either a constant value or a tag can be specified in this field. For this example, scaled data is being converted to a Fahrenheit scale. The temperature will never drop below freezing or a minimum engineering unit value of 32 degrees on the Fahrenheit scale.

Maximum Eng. Unit The highest value for scaled data. Either a constant value or a tag can be specified in this field. For this example, raw data is being read on the Fahrenheit scale. The temperature will never rise above boiling or a maximum engineering unit value of 212 degrees on the Celsius scale.



Deadband Value The amount, in either absolute value or percent of total value that, when applied, creates a range on either side of the value in which the recalculated value does not have to be written to the database. For this example, temperature changes of less than 2% in a short period of time are not of concern for this process. This would be reflected in a deadband value of 2 with PCT chosen for the Deadband Abs./Pct. field.

If a tag name is specified for the deadband value rather than an integer, no deadbanding occurs until a value is written to the specified tag from the database.

Deadband Abs./Pct.	Enter Absolute or Percentage to indicate if the deadband value specified is an absolute number of engineering units (EUs) or a percentage of the scaled value range. For this example, a deadband value of 2 percent (PCT) has been selected. Equivalently, since 2% of 180% Fahrenheit is 3.6 degrees, you could specify an absolute (ABS) deadband of 3.6.
Scaling Lock Tag	Use this field to temporarily disable the scaling feature for the scaled tag. When the Scaling Lock Tag has a non-zero value, changes made to the tag are not propagated to their related members. After the changes to that function have been made and the function has been re-enabled, the current raw value is scaled and written to the scaled value tag. In this example, if the incoming tank_temp data needed to be disabled temporarily in order to alter the temperature range, a scaling lock tag named disabl_temp could be specified. This tag would have the function of disabling the tank_temp tag. Once tank_temp has been changed, the user would need to come back to this table and remove disabl_temp from the Scaling Lock Tag field.

4 Click on Enter to save the data when you have completed entering all the information on this panel. If you have entered the names of any tags not already defined, the Tag Definition dialog is displayed.